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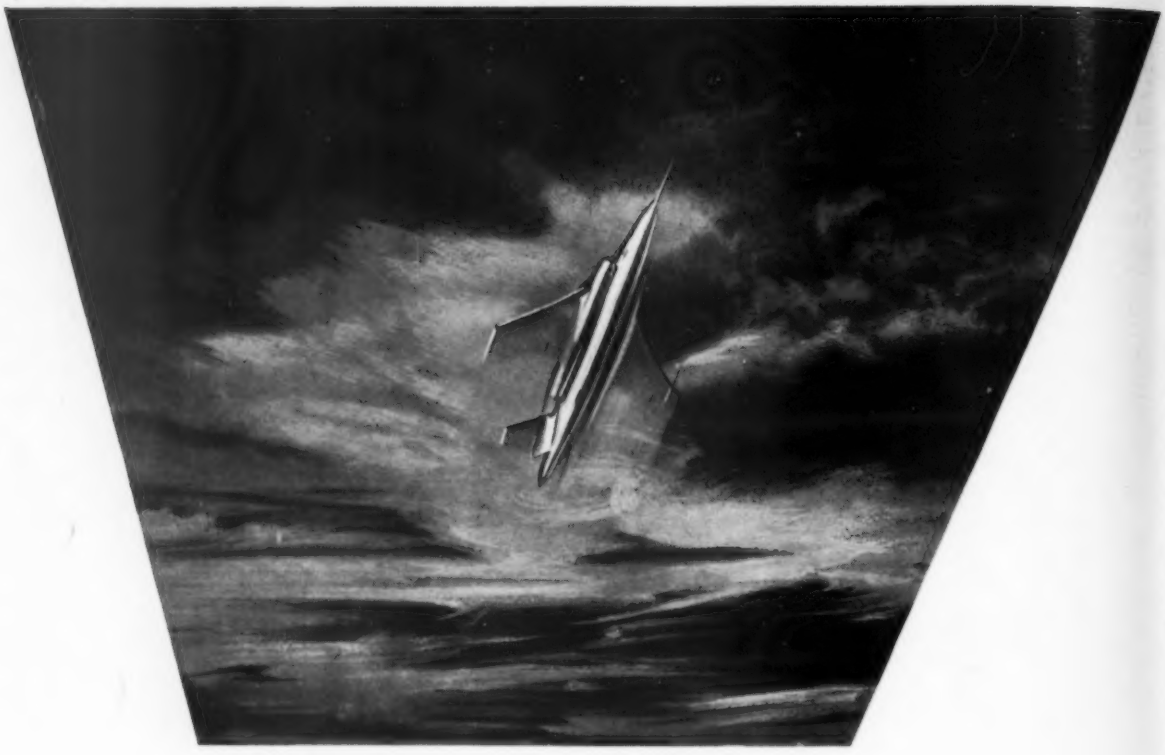

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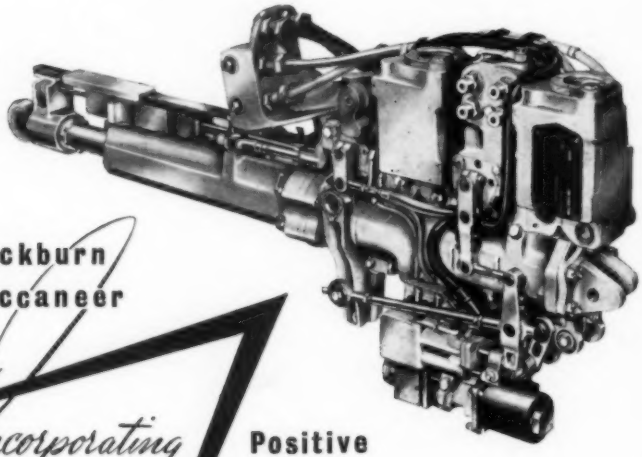

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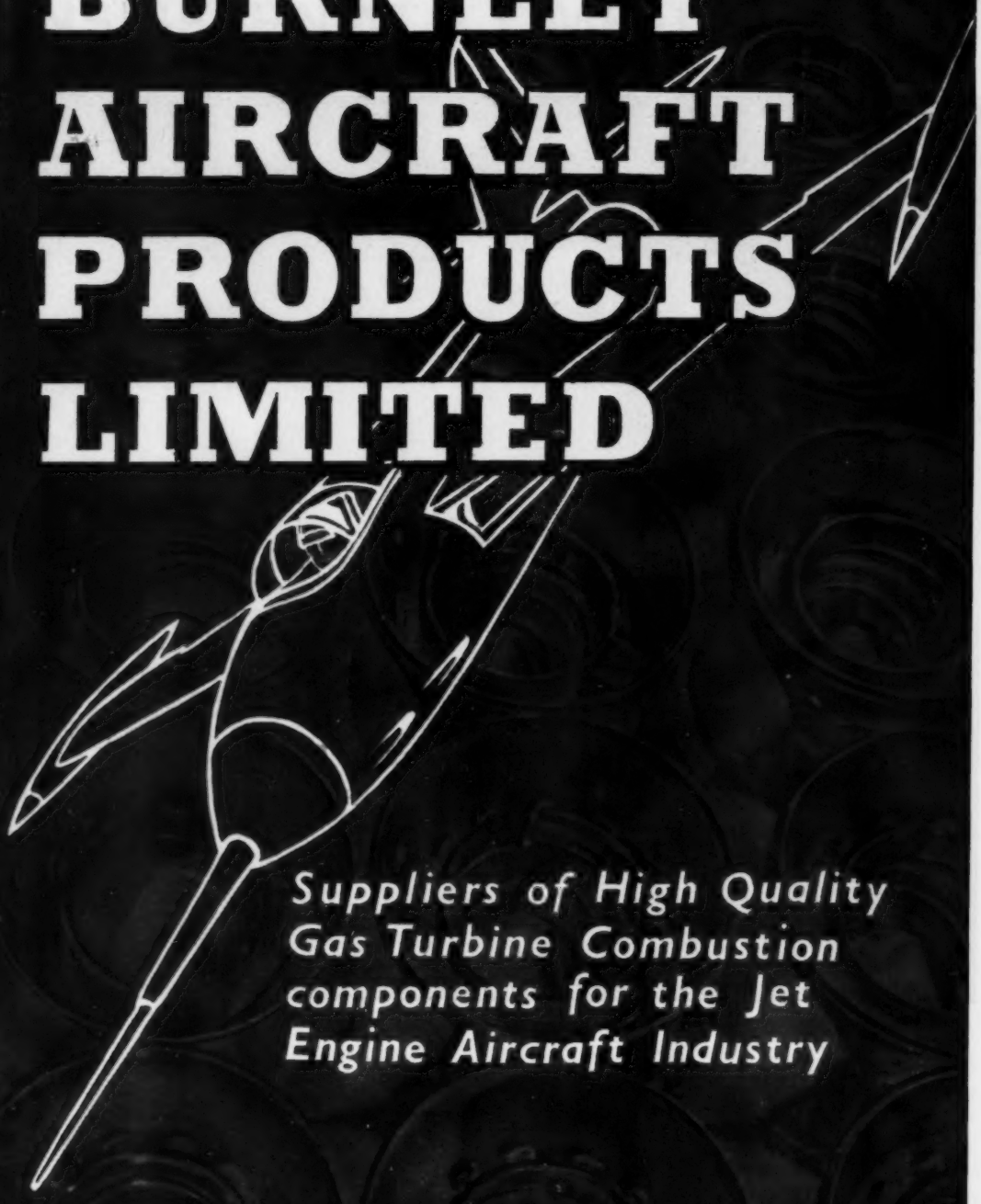

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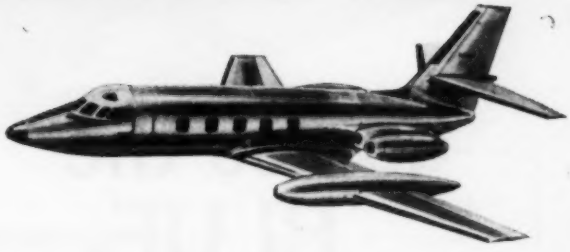

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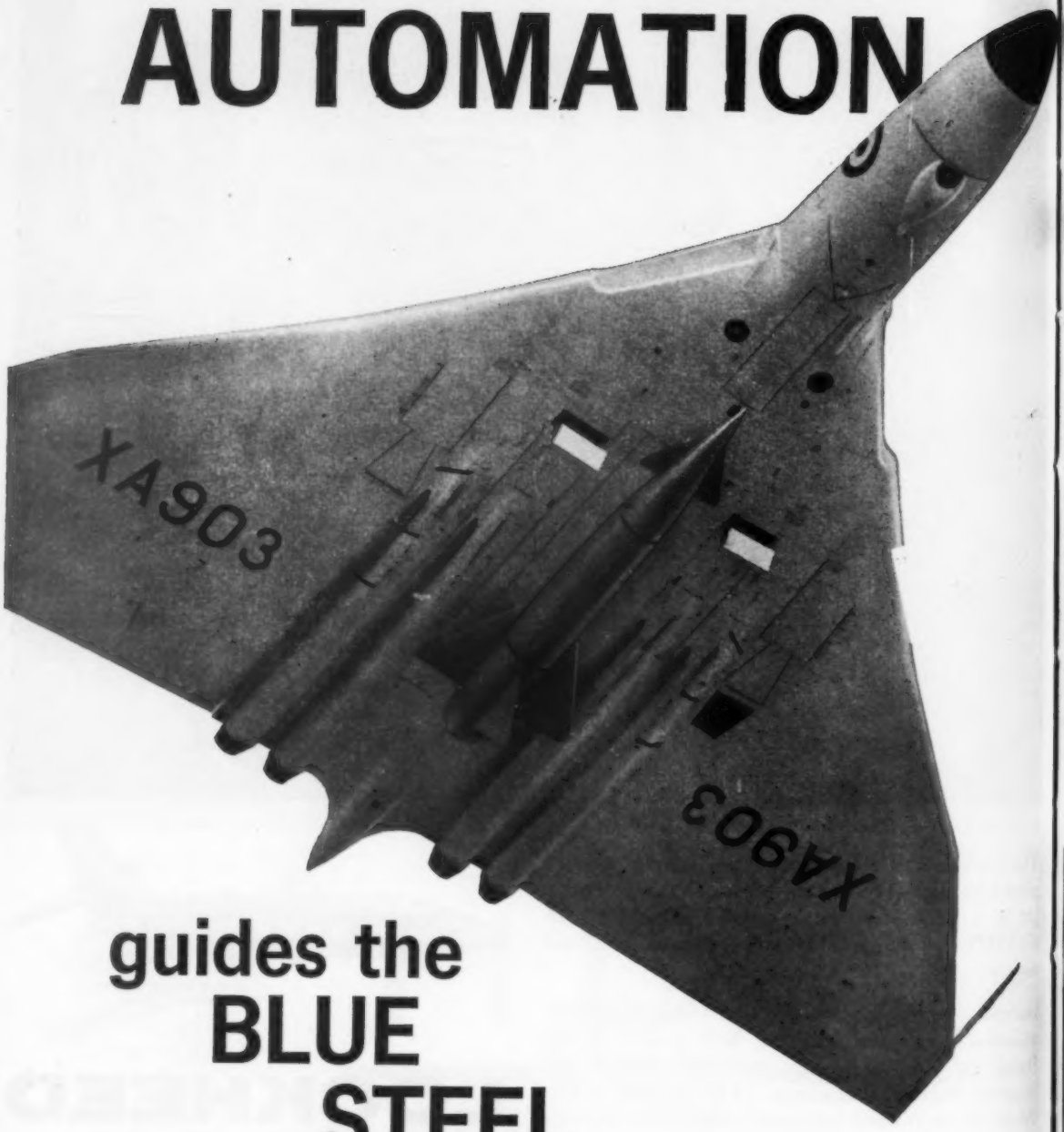

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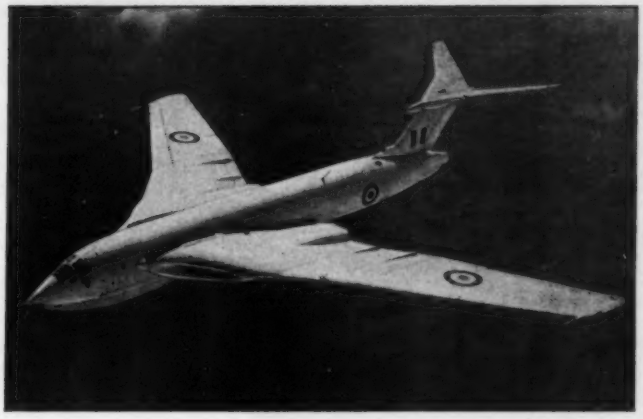

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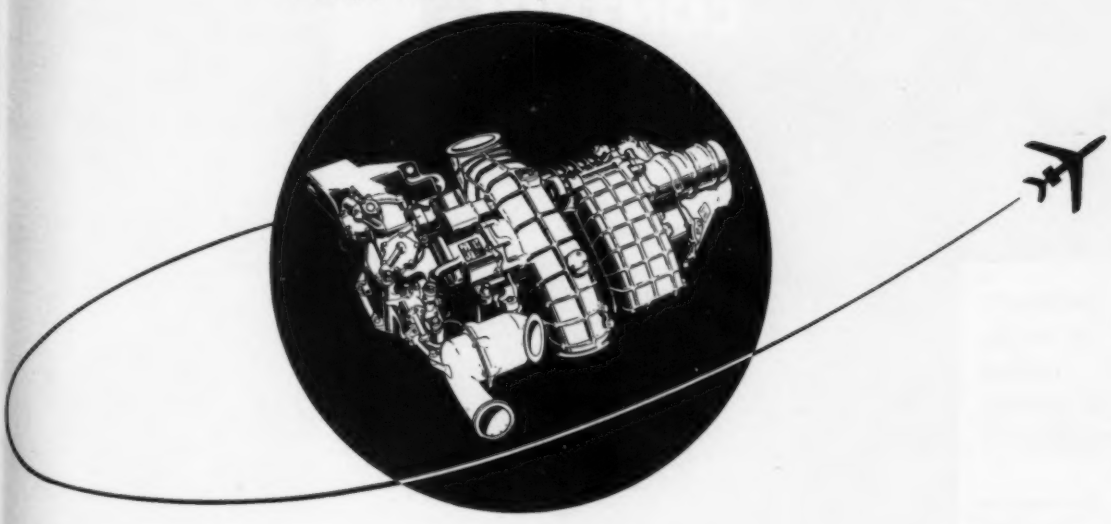

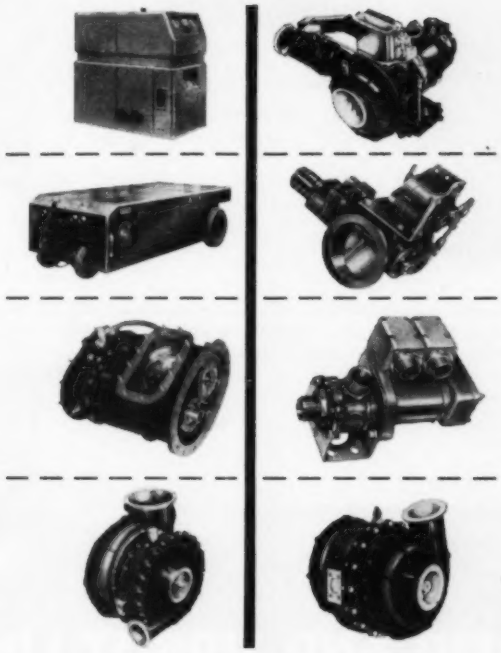

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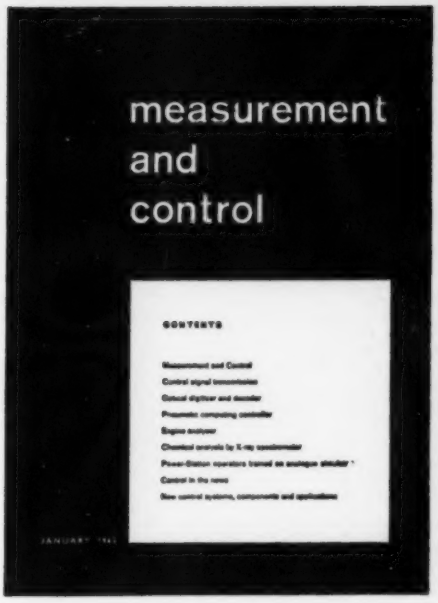

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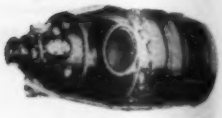

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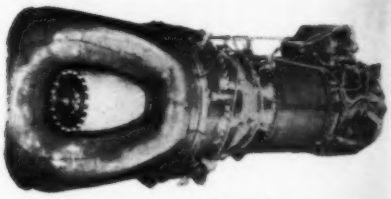

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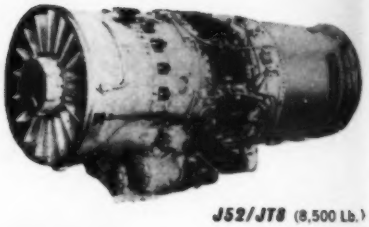

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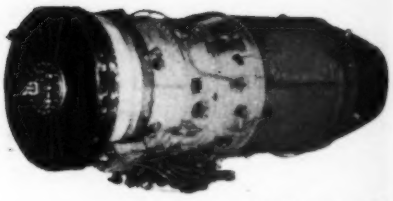

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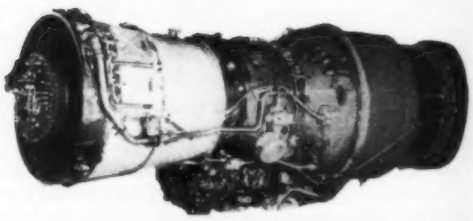

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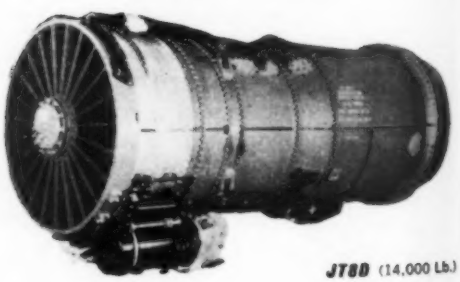

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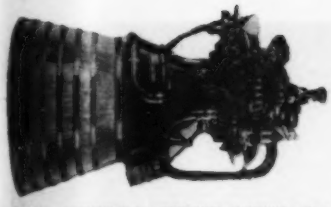

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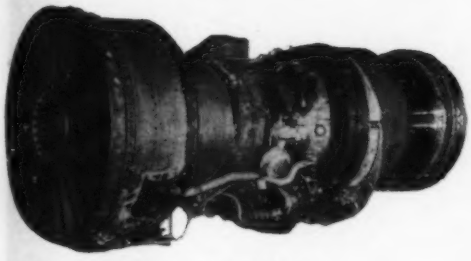

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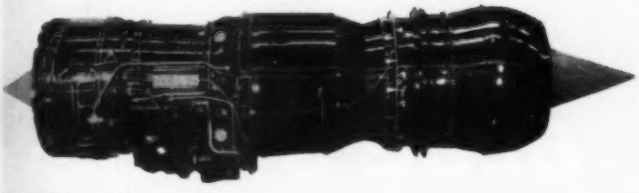

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FLIGHT

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Even in the Infantry . . .

LIKE the battleship and the heavily gunned bomber, the tank is considered by many students of modern warfare to have had its day; yet at the "Argus" demonstration of weapons and equipment at Chertsey last week (page 691) another of these monsters—the Chieftain—made its debut, rolling past a specimen of 1917 vintage without any apparent batting of Army eyelids. For it is increasingly argued that a weapon which was of only limited value in the First World War, and only really practical in the Second, can hardly be expected to render much account of itself in nuclear combat, when it can be located by radar and knocked out by a one-man-operated missile.

It would ill become us, as an aeronautical journal, to pontificate on the future of armoured fighting vehicles, even though the threat from guided weapons and aircraft is continually and obviously mounting. It is very much our province, on the other hand, to applaud the alertness of the Army to new trends, as manifested at last week's demonstration. Beyond all doubt, the "Brown Jobs" are becoming increasingly air-minded. They possess both offensive and defensive missiles; are employing radar to locate mortars and track mortar bombs in flight, and to provide intelligence of ground movements; and practice increasing co-operation with the RAF in land/air warfare techniques and air portability, both for soldiers and stores.

As a young Irish Guards officer put it at Chertsey, when the War Minister climbed aboard an Alouette to fly back to Westminster: "Even in the infantry, you've got to be air-minded nowadays."

A Choice of Feathers

DESIRING, in A.D. 1507, to transfer his person from the fair realm of England to the shores of France, John Damian equipped himself with wings. Having fallen to the ground from the top of Stirling Castle, causing him to "brak his theebane," he ventured the opinion that it was his choice of chicken feathers, instead of eagles', which had conferred a natural affinity for the "mydding" (midden) and not the "skyis."

Some similarly fine distinction may well decide the outcome of the imminent contest for the Henry Kremer prize of £5,000—for the first person to fly, in a man-powered aircraft, one mile, in a figure-eight course, around two pylons half a mile apart. Several projects are in hand, and financial assistance has been offered in respect of three designs—from a Southampton University group, the Hatfield Man-Powered Aircraft Club and a group at Southend.

As Mr Beverley Shenstone has lately reminded us, the available power for man-powered flight is so limited, and relatively incapable of development, that the great thing is "to fly at all, under cruising conditions." Nowadays, he remarks, we have laminar-flow wing sections to help us, and these alone could make the difference between success and failure. Initially (in Mr Shenstone's view) propellers will be used, although other possibilities, such as flapping wings and rotors, are possible, though more difficult. Extra drag caused by the position of the propeller, or its supporting structure, must be avoided; yet the propeller itself must be large—of the order of 9ft diameter. These are but a few considerations which call for the nicest judgment.

In the fair realm of England, then, we are soon to behold certain craftsmen and scholars attempting to rise to an age-old challenge. May they rise as on eagles' feathers. May they all stay out of the midden. And may God preserve their theebanes.

FROM ALL QUARTERS

Short/Lockheed F-104

ON October 30 it was announced that Short Brothers & Harland and Lockheed Aircraft Corporation are co-operating in the development of a VTOL version of the F-104G Super Starfighter to meet the NATO BMR-3 requirement (*Flight*, October 12). This competition, which closes on December 31, is for a new S/VTOL strike fighter to equip NATO air forces; and it is said that the Federal German Government, which would buy the largest quantity, are insisting on high supersonic speed. This the F-104 undoubtedly has, and the partners in the new version stress that its acceptance would "render unnecessary the development of a new aircraft." The VTOL F-104 will have British lift-engine nacelles mounted at the wing tips. It will probably have larger, low-pressure tyres, and will incorporate an autostabilization system derived from the type so successfully used in the SC.1.

Improved RAF and RN Aircraft

MENTION may now be made of a number of revised types of aircraft for the RAF and Royal Navy. Most important is the de Havilland Sea Vixen FAW.2, in which provision is made for carrying the new Red Top missile. Vixens of basically Mk 1 type have also been seen recently with large fuel tanks faired above the wing in line with the tail booms and projecting ahead of the leading edge; but this is probably still a trial installation. Hunter GA.11 is the designation applied to a batch of former RAF Hunter F.4 aircraft being modified for use as trainers by the Fleet Air Arm; they will have arrester hooks and some RN instrumentation, but no guns. The "Ground Attack" designation is new to the Service. Wasp HAS.1 is the Royal Navy's name for their future version of the Westland Nimbus-powered helicopter known to the Army as the Scout; and the RAF Transport Command Comet 4Cs will be known as Comet C.4.

ETPS Command Change

THERE is to be a change of command next month at the Empire Test Pilots' School, Farnborough. Capt K. R. Hickson, AFC, RN, is leaving to take up a new post as captain of RNAS Arbroath; he is being succeeded by Wg Cdr R. A. Watts, AFC, who has been Wg Cdr Flying at RAE Farnborough.

Capt Hickson has completed two tours of duty at Farnborough; before taking over as commandant of the ETPS last year—the first Naval officer to hold this post—he was Cdr Flying at the RAE. Wg Cdr Watts assumes his new post, with the acting rank of group captain, on December 15. Like Capt Hickson, the commandant-designate is an ETPS graduate.

Control of the P.1127

IN releasing some details of their electro-hydraulic powered-control unit for the Hawker P.1127, Fairey Engineering report that the prototypes have made 100 vertical take-offs and landings and several transitions from vertical to horizontal flight and back again. Many of these, the report states, were made without autostabilization. The three p.c.u.s provided for ailerons and tailplane are hydraulically fully duplicated and cater for both direct manual and electric inputs. In one mode of control, rate-gyros sense aircraft displacement from level altitude and apply corrective signals through the electrically controlled valves. Manual inputs by the pilot can override the electrical inputs. Alternatively, the manual inputs may be used alone without any autostabilization terms being added. It is also possible to feed autopilot signals into the electric valves to allow the aircraft to fly at pre-set course and height without manual intervention by the pilot. The control unit was illustrated in *Flight* for September 28, page 497.

It is significant that Hawker pilots have been able to fly the P.1127 without any stability augmentation. Short Brothers & Harland convincingly demonstrated that this could not be done when a *Flight* representative "flew" the SC.1 rig at Belfast in August (issue of August 24, page 274).

Alarm on Automatic Landing

A NOTE of alarm and despondency has recently been raised in the automatic landing field by a number of factually inaccurate reports which referred to failures, changes of heart and technical setbacks in the development of both airborne and ground-based equipment. Enquiries among customers and designers have, however, elicited nothing but spirited denials of most of the points raised. de Havilland, for instance, strongly deny that the radio altimeter flare-out system for the Trident has been found wanting. American tests of the altimeter have been most encouraging. BEA plans for the various stages of equipment which should lead to routine blind landing by 1970 are likely to be altered by earlier, rather than later, introduction of a full duplex automatic landing system with pvd stand-by.

The main area of research is in the guidance field, and the MoA is investigating improved ILS. This aid itself is protected internationally until 1975. In America, very large resources are being applied to development of basically new guidance, as well as improved ILS. British work is sadly meagre in comparison, but there is as yet no question of another American "bulldozer" move to implement their own system to our detriment.

Raytheon Acquires Cossor

AFTER a board meeting in London last week, Mr Charles F. Adams, chairman of Raytheon, announced that A. C. Cossor Ltd, whose shares the American company has bought for $6m, would retain its identity but be expanded and its sales potential strengthened. Cossor products were complementary to those of Raytheon, particularly in the secondary and primary radar fields and in weather radar; and a study would now be made to take full advantage of product and sales outlets. Raytheon already owned several European manufacturing, consultant and selling companies. The sales of Cossor communications radio were expected to reach a value of £1m during next year.

Mr R. V. Krafve, president of Raytheon, Mr Adams, chairman of the board, and Dr Carlo Calosi, vice-president of Raytheon-Europe, are joining the Cossor board.

Lady Cobham

WE recorded last week the death of Lady Cobham, wife of Sir Alan Cobham, at the age of 64. One who enjoyed the friendship of this most devoted of couples now writes in appreciation.

It was in 1922 (he recalls) that Alan Cobham met and married a handsome young woman named Gladys Lloyd, who gave up a stage career to share his chances as a pioneer in aviation. She proved to be a great personality in her own right and became well known and much admired in many spheres beyond immediate flying circles. Few women can have contributed so much to the happiness and success of a husband over a period of 40 strenuous years. From the beginning of their partnership she was at his right hand, consulted and contributing the practical woman's point of view on schemes both wild and woolly as well as the many others which were to make the name Cobham a household word in the history of British aviation.

Her life story was his—helping to plan the trial-blazing flights that were to culminate in the journey to Australia and back, which was recognized by the reward of a knighthood. As Lady Cobham she had the unique distinction of being a member of the crew on the next flight, a seven months' survey journey by flying-boat through and around Africa. She shared the trials on an adventu-

IN THE CLEAR: One of the problems associated with water-going hovercraft is that of spray, but it appears to have been largely overcome in Vickers-Armstrong's prototype hovercraft VA-1. This was evident in the first public demonstration of the craft over water (at Southampton last week) when, piloted by former Supermarine test pilot L. R. Colquhoun, it reached a speed of 30kt in difficult wind and sea conditions. This craft and subsequent models were described in "Flight" for October 5

ATLANTIC BAPTISM: Tomorrow at Toulouse Blagnac the Breguet Atlantic will be formally named by Madame Pierre Messmer, wife of the French Minister of Armed Forces, in the presence of representatives of France, Holland, Belgium and Germany, the countries participating in the programme. The Atlantic first flew on October 21

rous journey, undertaken to establish a British commercial air route from Cairo to the Cape. She was the hostess for her husband and the crew at many strange places visited for the first time by air. There was an unrehearsed call in a mangrove swamp in Liberia, where a forced landing entailed a wait for six weeks for spares. The only things notable about Grand Bassam were steam heat, mud, mosquitoes and, of course, the mangrove forest. How any woman could arrive back in England just a week or so later, still as a working member of the crew, looking bronzed and fresh enough to set out all over again, was quite memorable.

During the next few years it was a family life—two sons growing up, many functions to attend and a large circle of friends in aviation to entertain. Not only did Gladys Cobham's good looks compel attention but there was an infectious gaiety about her which ensured that the guests were happy and would depart hoping to be asked again. She took an active part in her husband's air display which toured the country and visited India before the war; and later, when his experimental flying activities were moved to Worcestershire, she ran the works canteen and joined the WVS. She had great charm and particularly a way with children, which endeared her to the many youngsters who made up the large Flight Refuelling family in later years at the towns and villages around Tarrant Rushton.

The Cobham enterprise was always a family concern, and Gladys filled the role of matriarch with distinction, regarded with great affection by all. She grew old gracefully, a handsome woman with a ready smile and a merry quip to cheer those around her. For her kindness to so many and her courage she will be remembered always.

C. W.

"Flight" Index

THE index to Vol 79 (January–June) 1961 of *Flight* is now available, price 1s (by post 1s 3d), from Associated Iliffe Press Ltd, Dorset House, Stamford Street, London SE1. Copies of this volume can be bound (with index) at a cost of 25s, return postage included; or binding case and index are available separately, price 7s 6d (by post 9s). Copies for binding (with sender's name and address enclosed) should be sent to Associated Iliffe Press Ltd, Binding Dept, 4/4a Iliffe Yard, London SE17, and advice and remittance forwarded to the publishing department at Dorset House.

IN BRIEF

Mr J. E. Serby, CB, CBE, has been appointed Deputy Controller of Guided Weapons at the MoA, and Mr R. E. Sainsbury has been made Director-General of Guided Weapons and Electronics Production. Both new appointments were being taken up immediately.

MoA has announced the appointment of Mr R. V. Whelpton as Director of the Signals Research and Development Establishment at Christchurch, Hants. He was taking up his new post at the beginning of this month.

The Procaer F.15/B demonstration announced for noon tomorrow (Friday, November 3) at West London Aero Club, White Waltham, has had to be postponed.

Mr E. Bellamy, AFRAeS, has joined Beagle as technical assistant to Mr J. W. P. Angell, group production manager. He was formerly chief production engineer with de Havilland Aircraft at Portsmouth.

The South-West Essex (Romford) branch of Air-Britain won the Air-Britain international cup for aircraft recognition in a competition held in Kensington, London, on October 21. A Royal Observer Corps team from Wallington, Surrey, were second.

Hordern-Richmond Ltd recently obtained US Federal Aviation Agency type design and installation approval for the manufacture of Bell and Hiller rotor blades. This approval, which covers the Bell 47 and Hiller VH-12 series, permits the company to supply blades for helicopter operators whose machines are on the US register.

A Yukon (CC-106) of 426 Sqn, RCAF Air Transport Command, recently made its maiden flight on a route which will be a regular one for these aircraft, from Trenton, Ont, to Marville in France. The eastward journey was made non-stop in 11hr 5mins, the return flight in 11hr 50mins. The Yukon is derived from the CL-44, Canadair-built version of the Bristol Britannia.

BEAGLE COMMERCIAL DIRECTOR and a director of Beagle-Auster Aircraft and of Beagle-Miles Aircraft: Sir Mark A. Norman, Bt, who will have charge of all the group's commercial activities. Formerly executive assistant to the managing director of Bristol Siddeley Engines, he takes up his new appointments on November 20 and will be based in London

SYSTEMS ENGINEERS at Vickers-Armstrongs (Aircraft): Mr H. Zeffert, AFRAeS, AssocIEE, MAIEE, and Mr M. H. Still, MSc(Eng), AMIMechE, ACGI, appointed chief systems engineer (E) and deputy chief systems engineer (E) respectively. Mr Zeffert will be in charge of the company's newly formed systems division

The annual dinner of the Association of British Aero Clubs and Centres will be held on February 9 next and not, as reported in last week's issue, on November 3.

Six airfields in France—Dreux in Normandy; and Chambley, Etain, Chaumont, Phalsbourg and Toul Rosiers in Eastern France—are being prepared to receive USAF reinforcements due in Europe soon.

Mr A. C. Jones, AMIMechE, AMInst Fuel, has been appointed an assistant general manager within the automatic control valves group of Elliott Brothers (London) Ltd. Before joining the company, he was manager of the Audco Controls Division of Audley Engineering Co Ltd.

Mr Trevor H. Tarr has been appointed sales publicity officer for the aircraft division of English Electric Aviation at Warton, Lancs; he will be responsible for publicity, press and public relations. Now in his twentieth year with the English Electric Co, Mr Tarr was previously chief instructor at an RAF technical school. For many years he was head of Napier technical publications, later becoming the company's deputy public relations manager.

The VTOL tactical strike/reconnaissance fighter being designed by Fokker in collaboration with Republic Aviation and designated D.24 is to be named "Alliance." This name has been chosen as suitable for an aircraft designed to equip NATO air forces; it also signifies Dutch-American partnership. Fokker fighter aircraft have always had designations prefixed by the letter "D" since the company was formed in 1919. Immediate predecessor of the Alliance was the D.23, a single-seat twin-engined aircraft with tractor and pusher propellers which first flew in May 1939. The prototype was damaged beyond repair in the bombing of Schiphol in 1940. Fokker report that the second phase of wind tunnel tests are under weigh for the D.24 Alliance.

Missiles and Spaceflight

EUROPE'S SPACE PROGRAMME

First Details of ESRO Plans: New Research and Data Centres Proposed

THE establishment of a European Space Technology Centre, a satellite-tracking and telemetry network, and a scientific programme ranging from sounding rockets to lunar orbiters and deep space probes are among the proposals presented to the European Preparatory Commission for Space Research—forerunner of the European Space Research Organization (ESRO)—at its third meeting in Munich last week. Although not yet official as far as the national governments involved are concerned, the programme put forward in the report of the scientific and technical working group to the meeting—and reported in detail for the first time in this article—will be the basis on which ESRO, when formed, will act.

As a probable major customer of the proposed European space launch-vehicle development organization, itself the subject of intergovernmental discussions in London this week, ESRO will obviously work in close co-operation with the launcher organization, if formed, although the working group's report makes it clear that no formal amalgamation would be favoured by ESRO. As the following brief history indicates, the preparatory commission has lost little time in getting things moving, and in particular the production of a detailed technical and scientific programme agreed by eleven countries in just over six months is a major achievement.

The European Preparatory Commission for Space Research was established by the intergovernmental agreement signed in Meyrin, Switzerland, on December 1, 1960, which came into force on February 27, 1961. The countries involved are Belgium, Denmark, France, West Germany, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom. The task of drafting a scientific programme was given to an interim scientific and technical working group set up at the first session of the Preparatory Commission held in Paris on March 13-14, 1961.

This group had to consider not only the scientific desirability of the proposed projects, but also the technological implications and the time, personnel and funds which would be required. The report presented at the Munich meeting of the Commission followed a briefer programme report submitted to the second meeting of the Commission in the Hague in May this year.

TABLE 1: PROPOSED EIGHT-YEAR PROGRAMME SCHEDULE

Years:	1	2	3	4	5	6	7	8
Short-term projects:								
Sounding rockets*	up to 10	40	65	65	65	65	65	65
Medium-term projects:								
Small satellites in near-Earth orbits	—	—	—	4	6	4	4	4
Space probes	—	—	—	—	—	2	3	3
Longer-term projects:								
Stabilized astronomical satellites	—	—	—	—	—	2	—	—
Lunar satellites	—	—	—	—	—	—	1	1

* Equivalent to a reference rocket capable of carrying 50kg payload to 150km.

The introduction to the working group's Munich report states that the main purpose of ESRO is to promote collaboration among European States in space research and technology, for which purpose it is necessary to establish a scientific forum. This forum should also guide the organization's scientific programme. To carry out this task, ESRO should provide for:—

(1) the immediate development of rocket payload, satellite and space probe technology to enable an agreed programme in space science to be undertaken

(2) applied research in a number of areas of space technology in order to offer better facilities for a more advanced programme in space science

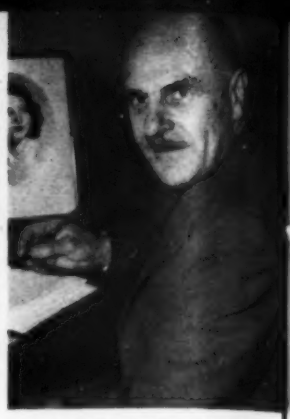
(3) applied research of a longer-term nature, associated with forward-looking assessments of space missions, in order to indicate the technical possibilities for space science

(4) opportunities for original research in space science beyond those which exist in the individual countries

(5) launching vehicles and their launching, although ESRO should not be responsible for the development and production of launching vehicles unless these cannot be satisfactorily obtained from a suitable source, and

(6) means for the collection, reception and analysis of data, relevant to its function as a space research organization.

ESRO should not compete, the report states, with universities and other research institutes in carrying out pure scientific research.



Sir Harrie Massey, president of the European Preparatory Commission for Space Research

Should a European launch vehicle organization be formed, close co-operation with it by ESRO would clearly be necessary, but it would be important for ESRO to retain its autonomy because the purpose and membership of the two organizations would be different.

The proposed fields of study could be divided into short-term projects using sounding rockets, medium-term projects using small satellites and space probes, and major long-term projects involving large satellites. The firings envisaged over an eight-year period from the formation of ESRO are shown in Table 1.

To carry out this programme and to act as a centre for applied research in space technology, the formation of a centralized European Space Technology Centre is considered essential. The functions of the centre would comprise the development and manufacture of rocket payloads, satellites and probes; applied research in space technology of a short-term nature; applied research of a long-term nature; and the assessment of possible scientific space missions based on forward-looking technical possibilities. Under the first heading, development and manufacture would be carried out both by the centre itself and by contract with European industry, universities and other research organizations.

TABLE 2: ESTIMATE OF EUROPEAN SPACE-SCIENCE MANPOWER RESOURCES

	Scientific groups who have flown experiments at present	Scientific groups planning experiments at present	Other groups interested in space research using ESRO facilities	Totals
Number of groups	15	25	15	55
Staff with PhD or equivalent ...	50	50	30	130
Other staff of graduate status ...	60	65	35	160
Number of technicians ...	75	85	40	200
				490

The report proposed, in addition to the space technology centre, a tracking and telemetry network linked to a European space data centre. This centre would be responsible for the collection, reduction and distribution of relevant data received from spacecraft and ground observatories, and for making predictions on satellite orbits and solar and geophysical events. The data centre would also provide facilities and services to assist ESRO and co-operating establishments in the scientific analysis of data.

The proposed scientific programme would involve the use of several launching ranges and the firing of different types of satellites' launching vehicles and sounding rockets. Because of the importance of a programme of sounding-rocket firings in the auroral zone and the absence of adequate existing facilities, it is suggested that ESRO should create a nothern range for such firings. The best site is believed to be that at Kiruna, Sweden.

These were the main points in summary from the working group's report. More detailed information on specific aspects of the report is contained in the following paragraphs.

Short-term Projects The short-term programme which ESRO might undertake immediately following its formation covers upper atmosphere physics for the auroral zone, upper atmosphere physics at lower latitudes and astronomical studies. All of these would be investigated by means of sounding rockets.

Medium-term projects Small satellites, each containing some five experiments, and small deep-space probes would be used in the proposed medium-term projects. The experiments listed would not demand any particular location of a launching range, and were all suitable for polar orbits. As part of this programme the report recommends that the European Space Technology Centre should develop recovery systems for satellites.

Long-term Projects The report proposed that one large project—the development and launching of stabilized satellite astronomical observatories—be commenced as soon as possible after the establishment of ESRO. After two years a second major project should be established, consisting of the development and

launching of lunar satellites to provide "a long-life interplanetary observatory captive to the lunar gravitational field and built to provide a basis for studies both of the interplanetary medium, streams and fields and of the Moon itself."

TABLE 3: PERFORMANCE OF MEDIUM-HEAVY LAUNCH VEHICLES CONSIDERED

Type	Payload (lb)		
	300 n.m. Circular orbit	5,000 n.m. Circular orbit	Circumlunar orbit
Atlas-Agena B	5,000	1,000	not available
Anglo-French Proposal			
(1) 2nd stage N_2O_4-UDMH 3rd stage HTP-Ker	2,400	500	not possible
(2) 2nd stage N_2O_4-UDMH 3rd stage H_2-O_2 (5,000lb)	3,700	1,600	750
(3) 2nd stage H_2-O_2 (20,000lb) no third stage	4,800	1,800	not available
(4) 2nd stage H_2-O_2 (30,000lb) no third stage	5,500	1,800	not available
(5) 2nd stage H_2-O_2 (20,000lb) 3rd stage H_2-O_2 (10,000lb)	6,000	2,600	not available

If a polar orbit were required, the payload would be decreased by about 10 per cent.

European Space Technology Centre The report proposes that this centre should be organized in three divisions, which would be responsible for projects, applied research and technical facilities respectively. The project division would develop and assemble certain rocket payloads and small satellites, and in addition would exercise technical and financial control of the development contracts in industry which would be particularly important for the larger satellite projects. The applied-research division would undertake development of techniques and new equipment in specific areas suggested by the project division, and would stimulate long-term applied research by its own activity, both short-term and long-term, and by contracts with other laboratories. The long-term applied research could include new methods of generation and storage of electrical energy, electric methods of propulsion, new methods of data storage, techniques of communication of data over great distances, application of solid-state circuits in the development of equipment, and passive methods of thermal control by means of surface coatings.

It is tentatively suggested that the project division might comprise three groups, one concerned with rocket payload engineering and the other two with satellite engineering. Both satellite groups would work on the smaller satellites and each would have in addition a major project—the astronomical earth satellite and the lunar satellite respectively. The applied research division could be divided into groups concerned with theoretical and dynamic analysis, instrumentation, control and stabilization techniques, power supplies, environmental testing, and materials and components.

Two particular research subjects detailed in the report were a Dutch suggestion for a sounding rocket capable of being launched in highly restricted areas, and an Italian proposal for applied research in advanced forms of propulsion and power generation. The working group recommends that ESRO should carry out a detailed assessment of the development and production of such a sounding rocket, while the need for applied research in the second area is agreed. In particular, ESRO's interest in electrical methods of propulsion for low levels of thrust both for control purposes and for the adjustment of orbits is stated to be valid whether or not such methods are investigated by the proposed European launch-vehicle organization.

Ranges (Sounding rockets) Sites at Nassarssuaq (Greenland), Andoya (Norway) and Kiruna (Sweden) were considered for firing sounding rockets in the auroral zone (between 65° and 72°N geomagnetic). The Kiruna site is believed to be the most suitable location, and a detailed study of this site has been made. "The creation of a northern range would probably be one of the first ESRO enterprises," the report states, "which would start almost immediately after signature of the convention."

For the limited number of medium-latitude sounding-rocket firings, existing national facilities might be used, provided the agreement of the countries involved could be obtained.

Ranges (Satellite launching) Although it would be convenient to have a range for launching satellites under the direct control of ESRO, the creation of such a new range did not appear to present any scientific advantage. ESRO should therefore:—

(1) use wherever possible "the ranges which have already been used for the development of the vehicles (Woomera for Blue Streak and Hammaguir for the French Diamant), on the assumption that ESRO would only have to support marginal costs,"

(2) use also, wherever possible, "one of the above ranges for firing US satellite launches if such vehicles were selected by ESRO, each specific case being separately studied," and

(3) "watch closely the opportunity to participate in the planning and use of a new range if another organization should initiate such a project."

According to the National Aeronautics and Space Administration, the report states, the addition of one launching complex to an existing well-equipped range would cost 7.5m NF (£543,000) for Scout, 60m NF (£4.4m) for Thor-Agena B and 100m NF (£7.2m) for Atlas-Agena B.

Satellite Launching Vehicles The report states: "The proposed programme of ESRO does not include the development of satellite and deep space probe launching vehicles; the following discussion therefore deals only with those topics which are directly pertinent to ESRO planning. It appears highly desirable, however, to establish a close co-operation between ESRO and the European organization for vehicle development, if such an organization is created.

"The choice of a satellite launching vehicle or deep space probe would be primarily determined by the following criteria:—

(a) the payload capability in a specific orbit or, in the case of the deep space probe, the apogee height,

(b) the availability of the launching vehicles, both from the point of view of the time required before the launching system would be in an operational condition and the continuance of supply,

(c) the cost of firing the satellite launching vehicle, this cost falling into the three parts:

(1) cost of the vehicle,

(2) operational cost of firing the vehicle,

(3) cost of capital support equipment,

(d) the need to maintain the maximum degree of standardization in vehicles for the various missions which might arise . . .

TABLE 4: COSTS AND LEAD TIMES OF LIGHT LAUNCH VEHICLES CONSIDERED

Type	Cost per vehicle* (million NF)	(thous. £)	Lead time (months)
Scout	3.75 (4.675 has also been quoted)	270 340	12 for US launching; ? for launching elsewhere
Black Knight + Solid-propellant 2nd and 3rd stages	1.75	127	18 approx
French launcher + Solid-propellant 2nd and 3rd stages	1.70	123	40 approx

* Development costs are not included in these figures.

"The probable ESRO requirements for satellite and deep space probe launchers might be summarized somewhat arbitrarily as follows: a light launcher weighing 20 tons and capable of placing 100-500lb in orbit at 300 n.m., and a medium-heavy vehicle weighing 100 tons, built to place 2,000-5,000lb in the same orbit . . .

"The Thor vehicle does not seem to fit the European requirement for standardization. Indeed, with its 50 ton gross weight, it would be too expensive and heavy for orbiting simple and small satellites, while it would not be capable of launching the complex payloads required for the advanced missions contemplated (the astronomical observation satellite and the Moon orbiter)."

Medium-heavy launch vehicles "In order to indicate in a simple way the capability of the possible launching vehicles, only two types of orbits are considered here: a circular near-Earth orbit (300 n.m.); and a high circular orbit (5,000 n.m.).

"For Atlas-Agena B, the following figures have been quoted by NASA:—

Vehicle cost (Basic vehicle)	25m NF (£1.8m)
System engineering and launching cost	16.5m NF (£1.2m)
Lead time for vehicle	21 months
Launch site cost	100m NF (£7.2)

"The table (Table 3) summarizes the figures in relation to the two possibilities, i.e., the Atlas-Agena B which is the only medium-heavy vehicle mentioned by NASA as possibly being made available to a European organization, and the Anglo-French proposal based on the use of Blue Streak as the first stage.

"Detailed planning for the development of a European launching vehicle based on Blue Streak is contained in the 'Anglo-French Technical Proposals for the Development of a Satellite Launching System' (reported in *Flight* of February 17). It is estimated that such development would take four-and-a-half years. According to recent UK figures, the cost of the Blue Streak first stage is known to be close to 7m NF (£507,000).

"No figures are currently available for the upper stages, but the best available estimates give the total cost of the vehicle as 10.5m NF (£766,000), and the marginal cost per launch as 18.9m NF (£1.37m).

Missiles and Spaceflight . . .

"In attempting to state the cost of firings it is essential that the basis of the cost should be clearly defined and in particular that the difference between factor cost and marginal cost should be appreciated.

"By the factor cost of a launch is meant the total cost of the European launcher organization over a given period divided by the number of satellites launched in the period. It bears the cost of all the research and development activity of the launcher organization as well as maintenance of facilities. It contains a large fixed element and is highly dependent on the number of rounds fired. During the last development year of the first programme of the launcher organization three rounds will be fired and the factor cost will be about £5m per round. In later years, under smooth production, the factor cost should be between £2m and £3m per launch for rates between three and seven firings per year.

"By 'Marginal Cost' is meant the cost per launch of additional rounds, for example, the additional cost per round of firing six rounds instead of three. This cost does not vary very much with the number of additional rounds. It is found to bear a reasonably fixed relationship to the 'factory gate' cost of the hardware.

"An analysis of three different American satellite launcher programmes gives ratios of cost per launch divided by hardware cost of 1.66, 1.71 and 1.72 respectively. In each case the cost of the firing team was not fully charged, being shared with other users, and therefore the ratios might be a little low compared with an unshared range cost. An accurate analysis for Black Knight resulted in a ratio of 1.75, and for Blue Streak as a first stage of a European satellite launcher a figure of 1.8 has recently been obtained.

"For these reasons it has been assumed that the marginal cost per launch of the three-stage European launcher will be about 1.8 times the hardware cost . . .

Light launch vehicles "In the light launching vehicle category, the preliminary choice was finally limited to three possibilities:—

A. *Scout* (*United States*)

This vehicle is already developed and almost fully qualified. Scout's capability can be summarized as follows:—

Orbit	Payload (East launch)
Circular (600km)	65kg
Circular (1,500km)	12kg
Elliptical (400km perigee and 3,000km apogee)	50kg

B. *Diamant* (*France*)

This French proposal is based on a first stage vehicle at present under development. Its capability, with two solid-propellant upper stages, is roughly twice that of the Scout; it could be significantly increased by using liquid hydrogen upper stages.

C. *Modified Black Knight* (*United Kingdom*)

A preliminary study has been made in the United Kingdom for adapting the Black Knight for satellite launching. The preliminary calculations can be summarized as follows:—

1st Black Knight, 2nd and 3rd solid } 50kg in 800km circular orbit (east)

1st Black Knight with booster, 2nd liquid hydrogen-lox } 120kg in 800km circular orbit (east)

"The table (Table 4) gives the approximate estimate of cost and lead time of these three possibilities."

Cost of the Programme The total cost for the eight-year programme, including the ESRO research group and fellowships, European space technology centre, launching costs, vehicles, tracking and telemetry, and data handling, is estimated to be 1,393.1m NF, or approximately £101m. The technology centre would have 250-300 scientific and engineering staff out of a total complement of 800; while the data centre and tracking and telemetry stations would employ a total of 155 people.

The proposed northern range at Kiruna, which would have a total complement of 90, including 30 specialists, would involve an estimated capital cost of 17.1m NF (£1.24m) and normal running costs of 5.3m NF (£380,000). The "standard" sounding rocket is estimated at two-thirds of the cost of Skylark, i.e., approximately 84,000 NF (£6,100).

Launching costs for small satellites are based on Scout, at 4.5m NF (£326,000) for the vehicle cost and the same amount for launching cost. For space probes and large satellites the costs are based on Blue Streak figures provided by the Ministry of Aviation. For the complete vehicle the cost is assumed to be 9.7m NF (£703,000), again with an equivalent sum to cover the cost of launching.

(To be concluded)

SATURN SUCCESS

The first flight test of a Saturn C-1 vehicle, with live first stage and dummy upper stages, was successfully completed by the National Aeronautics and Space Administration from Cape Canaveral on October 27. The rocket was programmed to fly a distance of some 225 miles down the Atlantic Missile Range and to achieve a peak altitude of about 90 miles. Officials stated that impact was achieved about six-and-a-half miles from the target, after an eight-minute flight.

Saturn lift-off, October 27

The major objectives of the flight were:

(1) To prove the operation of launch facilities for Saturn vehicles, for example propellant supply system, ground support equipment, automatic checkout equipment, instrumentation and launch pedestal,

(2) To determine the in-flight performance of the eight-engined booster stage, the controlling movements of the four gimballed engines, and engine cut-off and propellant utilization, and

(3) To verify the structual integrity of the airframe of the vehicle, evaluating stress at critical moments of flight and determining vibration and bending values.

Other flight objectives were to confirm aerodynamic characteristics, correlating predicted stability and performance with that encountered in flight, and to demonstrate the capability of the modified ST-90 stabilized platform in the guidance and control system.

In the first flight test the eight Rocketdyne H-1 engines comprising the S-1 booster stage were rated at 165,000lb of thrust each, giving a stage thrust of 1,320,000lb. The S-4 second stage was inert and carried some 90,000lb of water ballast, and the S-5 third stage was also inert and carried 100,000lb of water ballast. The operational S-4 stage will be powered by six 15,000lb thrust Pratt & Whitney RL-10 liquid hydrogen/liquid oxygen engines; and the S-5 stage will be a Centaur (two RL-10s) modified for use on Saturn. The dummy payload for the first flight was the nose section of a Jupiter missile.

SATURN C-1 LAUNCH SCHEDULE

Vehicle Description	Launchings per Calendar Year			
	1961	1962	1963	1964
Research and development, with inert upper stages and simulated payload	1	2	1	—
Research and development, S-1 and S-4 with simulated payload	—	—	2	—
Research and development, S-1 and S-4 with boilerplate Apollo payload	—	—	2	2

A series of ten research and development launchings is planned, which are expected to lead to an operational C-1 vehicle in 1964, and to an advanced Saturn shortly thereafter. The C-1 will be used to place a three-man Apollo spacecraft in Earth orbit; while the advanced Saturn is expected to take a three-man crew to lunar orbit and return in preparation for manned lunar landings.

The George C. Marshall Space Flight Center, whose personnel developed and launched the Jupiter C, Juno 2 and Mercury-Redstone vehicles, is fabricating and assembling the first ten Saturn test-flight boosters and the four inert S-4 stages, and is conducting related research throughout the programme.

EUROPEAN LAUNCHER PLANS DISCUSSED

Representatives from Britain, France, six other European countries and Australia were expected to attend the intergovernmental conference to discuss the Anglo-French proposals for a five-year European space launcher development programme, which opened in London on Monday last, October 30. The six European countries are Belgium, Denmark, West Germany, the Netherlands, Italy and Spain; in addition, observers were invited from Norway, Sweden and Switzerland. Announcing the conference on October 25, the Ministry of Aviation described its purpose as "to complete the arrangements for a European launcher development organization, based on the Anglo-French proposals."

Lord Brabazon, Sir Frederick Handley Page and Mr Peter Masefield at the RAeC gathering. At right, precision-cast stainless steel "Brab," by caricaturist Gordon Olding, presented to its subject on behalf of an anonymous member

Two Jubilees

CLUB'S DIAMOND AND PILOTS' GOLDEN ANNIVERSARIES

"IN 1907 I got Short Brothers, who built balloons, to build me an aeroplane. It never looked as if it would get in the air, nor did it . . ." The speaker, of course, was Lord Brabazon of Tara, president of the Royal Aero Club, committee-member for the past 57 years, and main speaker at the club's 60th anniversary dinner on October 25. Denying that he knew Leonardo da Vinci well, Brab dipped into the bran-tub of his memory and brought out a miscellany of recollections—of the formation of the club, of people and of events which had affected its history, of the Wrights' flights in Europe, of the rival Aeroplane Club, "which was at that time a terrible nuisance."

As for the present, no club had a greater goodwill within itself, he emphasized, or a greater sense of purpose for the future. The forthcoming move to the Lansdowne Club's premises at Berkeley Square was a great step forward.

Another jubilee celebrated last week, also illustrated here, marked the 50 (or more) years' tenure of Service flying licences—held by Air Commodore G. B. Dacre and his colleagues, for whom he organized a reunion party in London on October 24.

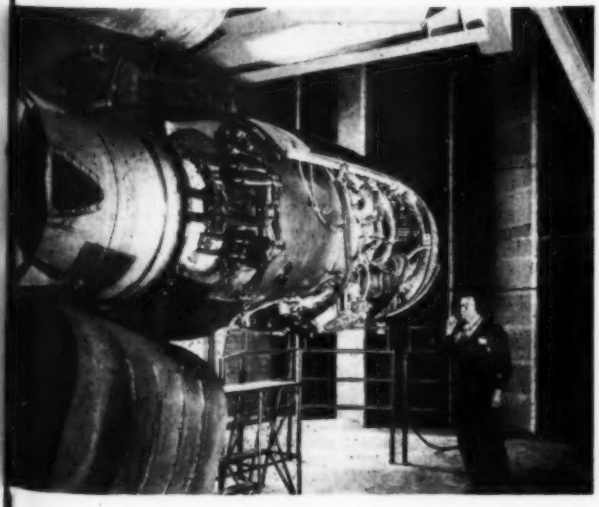
Pre-First World War Service pilots with the Air Minister, Mr Julian Amery (standing, second from right), at last week's reunion. Left to right (seated): Vice-Admiral R. B. Davies, VC, CB, DSO; Maj H. A. Petre, DSO, MC; AVM A. E. Borton, CB, CMG, DSO, AFC. Standing: Air Cdre G. B. Dacre, CBE, DSO; Gp Capt H. A. Williamson, CMG; Lt-Col C. L'Estrange Malone, FRAeS

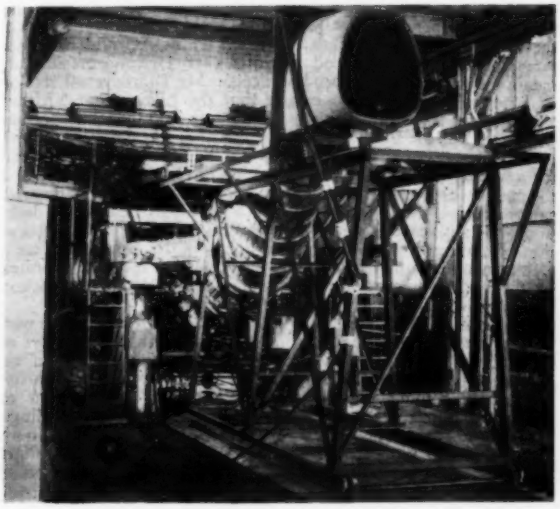
NINE MONTHS' EXPORTS

EXPORTS by the British aircraft industry during the first nine months of this year amounted to £118¼m, of which £48m worth were dollar sales. This nine months' total was some £10m more than in the same period for 1960 and represents an annual figure of £158m. The exact total, £118,418,638, was made up as follows: aircraft and parts, £48,632,828; engines, £64,180,024; electrical equipment, £2,813,451; instruments, £2,071,369; and tyres, £720,966. Canada and the United States were the biggest customers both for aircraft and engines, Canada spending £15,638,410 on aircraft and £14,299,201 on engines, and the US respectively £6,193,803 and £12,219,944.

Exports for September amounted to £9,503,246, made up as follows: aircraft, £2,512,692; engines, £6,485,306; electrical equipment, £243,191; instruments, £197,460; and tyres, £64,597.

TRIBUTARIES of the de Havilland Trident's triple powerplant (three Rolls-Royce Speys) are depicted in these two new pictures from Rolls-Royce's Hucknall establishment. On the left, one of the lateral pods is shown complete with all accessories and with its thrust-reverser system and noise-suppressor nozzle; and on the right is seen the installation of the centre unit, with its long S-shaped air duct. Running time on test engines now totals over 1,300hr, including a preliminary 150hr run to the combined ARB and FAA type-test schedule





AIR COMMERCE

A new picture of the first de Havilland Trident, which is due to fly before the end of the year, undergoing engine runs at Hatfield. Ground running with three Rolls-Royce Speys installed has been completed. *(See also page 681)*

British United's Report

TO be welcomed in its own right, and as a gesture worthy of repetition by other independents, is last week's publication by British United Airways of an annual report and accounts for 1960. In the past it has been necessary to probe into the dusty files of Bush House in London to learn the basic financial facts of a private company's life. Now the accounts of Britain's largest independent are shown to a wider audience. They suggest that British United is not to be grouped with those independents whose wobbly finances have been so much in the news lately.

But this is not really an airline report in the sense that it tells the story of the company's operations, fleet, routes, revenues, expenses, traffic, and so on. There is no information about any of these aspects of its work; the report is essentially a balance sheet. And, in analysing the balances, it is necessary to distinguish between the airline which trades under that name and the two dozen other companies which, together with the airline, comprise the group. Included in the latter category are such important units as Aviation Traders (Engineering), Channel Air Bridge, Morton/Olley Air Services, Straits Air Freight Express of New Zealand, and one of the biggest commercial helicopter concerns in the world.

Taking the group as a whole, the consolidated balance sheet shows a net value of almost £12m, over £10m of which consists of fixed assets. Of these fixed assets, 90 per cent of which are aircraft, the airline British United holds just under £5m while the other companies hold just under £6m. The first fact, then, that emerges from the balance sheet is that British United as an airline represents just under one half of British United as a group.

The main source of finance for the organization is in the form of long-term debt. This stood at £4.7m at the end of 1960. This is followed by £3m received from the issue of shares, and accumulated capital profits of £1.6m from the sale of fixed assets, mostly aircraft. Operating profits do not appear as a significant source of finance, a small accumulated operating profit by the airline British United having apparently been largely dissipated in other quarters.

The group's operating profit in 1960 amounted to just over £400,000. This figure is increased to just over £500,000 when account is taken of the receipt of income tax refunds, this presumably being due to the take-over of businesses which enjoyed, from an income tax point of view, an accumulated loss.

To what extent this £0.5m profit is due to the airline British United or to other members of the group is not clear. However, a significant footnote to the profit and loss accounts does suggest that the airline British United actually lost £187,739 in 1960, as against a profit of £63,672 in 1959. From this it must be supposed that the group's profits last year were realized on operations other than those bearing the British United label.

No details of revenues are given, but in terms of the earning power of assets it is possible to hazard a guess at a revenue figure for the group of the order of £15m, with the airline accounting for just under half of the total. These figures are confirmed by a rough calculation based on the British United operating and traffic statistics published by IATA. On the basis of the airline's known production capacity of 51m c.t.m. in 1960 (23m scheduled, 28m non-scheduled), British United's total expenditure was probably not far off £6m.

The first broad fact that emerges from this report—that British United as an airline represents just under one half of the group as a whole—is confirmed by employment statistics. Whereas IATA gives a figure of 1,192 staff at the year-end for British United, the chairman's covering letter to the report includes a reference to a total group employment of over 3,000 people.

The accounts of the group as a whole display a healthy financial position, the non-British United parts of the organization being comfortably able to sustain the losses almost inevitably incurred by the airline in a year described by the chairman as "a period of reorganization and rationalization," which included the merger with Hunting-Clan. A high level of activity in 1961 leads Mr Myles Wyatt to indulge in subdued optimism for the current year.

MORE QUESTIONS IN THE HOUSE

MORE questions have been asked in the House as a result of Parliamentary concern over recent accidents. Mr Driberg asked the Minister if, in the course of accident investigations, he would pay particular attention to the standard of efficiency required of independent pilots, and if he would ascertain, and inform the House, how many pilots dismissed by BOAC and BEA are now flying "privately-owned aircraft" (Mr Driberg presumably meant aircraft of the independent fleets). Mr Thorneycroft replied that he was concerned to ensure that the highest standards of efficiency are met by all British airline pilots, and that the information regarding the second half of the question was not available.

Mr Snow asked the Minister whether he was aware of the need for a speedy reconciliation of the rights of charter companies and the need to protect the public against contraventions or inadequate safety control. Mr Snow also asked whether, in view of the delay in dealing with cases involving air transport safety and the publication of findings by his Inspectorate, the Minister would institute a Departmental enquiry to examine the American method, operated by the FAA, whereby speedier findings are published and action taken against delinquent air transport companies.

In answer to this question, Mr Thorneycroft explained the purpose of the air operators' certificate, and said that the report of the Cairns Committee on accident investigation published on March 1 (and on whose specific recommendations the Minister has not yet commented), did not suggest that the adoption of different methods in this country would result in speedier findings.

Mr Mason asked the Minister what facts he had elicited from his recent flight to Norway; Mr Thorneycroft replied that his flight was made to enable him to understand the final accident report of the Norwegian authorities.

BREVITIES

Riddle Airlines Inc is negotiating for the purchase of ten more DC-7Cs to add to the ten of this type it already has.

Air Marshal Sir Andrew McKee is to resign from the board of de Havilland Aircraft Co of New Zealand Ltd to take up an appointment on the board of TEAL.

RAF Aldergrove is to be the new civil airport for Northern Ireland, replacing Nutts Corner, which is now too small. A terminal building and apron costing an estimated £750,000 is to be built and will be ready by 1963.

KLM has selected Luton as its main diversionary airport to London (Heathrow) in place of Gatwick, Stansted or Southend. The first diversion, a Viscount, was on October 30. Lutair Handling Services Ltd are handling KLM.

The Darts of TCA's Viscounts are now approved for operating 3,500hr between overhauls, the world's longest engine overhaul life. The Allison 501-D13s of Eastern's and Pacific Southwest's Electras have recently had their overhaul life increased from 1,800 to 2,000hr.

Keegan Aviation Ltd announced last week the purchase by "an associated company" (understood to be Airline Air Spares Ltd) of eleven ex-TCA Canadair North Stars previously operated by Overseas Aviation (CI) Ltd. Mr Keegan last week declined to disclose the purchase price.

Although BOAC has guaranteed Air Ceylon no losses during the first year of its chartered Comet 4 operations, Mr Basil Smallpeice, speaking in Ceylon, said that a profitable operation will be possible because Air Ceylon will operate within the tripartite Air-India/Qantas/BOAC pool agreement. BOAC will have no financial interest in Air Ceylon. Details of the charter agreement could not, Mr Smallpeice said, be disclosed. Air Ceylon is reported to be expecting a deficit of RsC1½m (£115,000) in 1961.

The president of Panair do Brasil, Dr Paulo Sampaio (left) after signing for four Sud-Aviation Caravelles. On the right is M Georges Hereil, director-general of the French company; in the centre is Mr W. J. Jakimiuk, Sud's sales director

SURPRISE FOR THE RAILWAYS

THERE is a passage in the licensing regulations* which gives surface operators the opportunity, which British Railways have seized, to object to applications for air service licences. One of the matters which the Air Transport Licensing Board has to take into account when considering applications for air service licences is (to paraphrase Section 2(2)(h) of the Act) any objection made in accordance with that particular bit in the regulations.

British Railways have argued that the Board is required by the Act to take into account, in the public interest, the effect on their traffic of new air services. This contention has now been dismissed by Sir Ralph Hone, the commissioner who heard British Railways' appeal against the Board's decision to grant Morton Air Services a licence to operate between Swansea and Birmingham. Sir Ralph Hone recommends the rejection of British Railways' appeal, a recommendation which the Minister has accepted.

But the Minister, while accepting Sir Ralph's recommendation, springs a major surprise. He says, in so many words, that Sir Ralph is wrong in his view that the Board need not consider the question of wasteful competition with the Railways. This will encourage the Railways, who are now likely to appeal against BEA's recently awarded 3gns night fares to Scotland and Northern Ireland (*Flight*, October 26, page 672). But the outcome would appear, in the light of Sir Ralph Hone's recommendations, to be a foregone conclusion.

The Railways have put up and continue to put up a strong fight against air competition. They feel, quite rightly, that their services demand protection in the public interest—the two key words that were never, despite pressure, included in the definition of the ATLB's duty in the Civil Aviation Licensing Act, 1960.

FINGERS FOR NEW TERMINAL?

ACCORDING to an announcement in *BOAC News*, permanent finger structures for passenger loading and unloading are being provided by the Ministry at the new long-haul terminal at London Heathrow. The statement adds that the corporation is pressing for fingers to be provided as quickly as possible, not only for the primary purpose of handling passengers, but also for use (at ground level) as engineering offices. As reported in *Flight* for September 21, BOAC will initially use temporary huts for ramp services.

This is the first time that the contentious subject of fingers has been mentioned officially in connection with the new long-haul terminal at London Heathrow. Asked to comment, a Ministry of Aviation spokesman said that no decision had yet been taken, and that no decision was likely before requirements had been assessed after the building is opened later this year.

Meanwhile, BOAC are installing in the new terminal a conveyor on the baggage loading dock. Passenger baggage will move to the air side of the terminal from the ticket counter *via* a Ministry-installed underground conveyor system. At the air side this connects with the BOAC conveyor which, by means of hydraulic arms, directs baggage to the appropriate collection points. BOAC passengers, and those airline passengers who are handled by BOAC, will depart from the new terminal from November 13.

STIFF AS A BOARD

THE Air Transport Licensing Board, a body with a voice of its own, had some unfavourable comments to make in its first report (summarized last week) about its offices in Therese House. The Board moved there from 3 Dean's Yard, Westminster, on March 27 to enable all its staff to be housed under one roof.

The report expresses the Board's misgivings about the suitability of the location of Therese House near the junction of Goswell Road and Clerkenwell Road (its exact address is 29-30 Glasshouse Yard, London, EC1.) The Board points out that most of those attending Board meetings, whether airline officials or travel agents, have their London offices in the West End or to the west side of London and find considerable inconvenience reaching Therese House through a congested traffic area. "Apart from this," the report continues, "the building is in a depressing and unattractive area of bombed sites, dilapidated premises and intensive building activity; and the external noise, which seems likely to go on for a very long time, is a major nuisance." (It would be ironical if a London Borough Councillor objecting to a proposed helicopter service on the grounds of noise could not make himself heard by the Board!)

During the peak period when applications for summer holiday services are being heard, the Board can decide to sit in two divisions; unfortunately, the report notes, no space has been provided in Therese House. And if other accommodation has to be hired, there will be the inconvenience of Board members, their staff and documents having to transfer to the hired accommodation while ensuring co-ordination between the two divisions. This will also be inconvenient to people needing to attend hearings at both places in the same morning or afternoon.

The air conditioning at Therese House is said (not by the report) to be so bad that those attending recent hearings were "frozen stiff"; unfortunately, the key to the air conditioning controls has to be obtained from Lambeth House some way away.

BRITISH UNITED'S REAPPRAISAL

BRITISH UNITED AIRWAYS has withdrawn its original applications for services to the Far East. In addition it has withdrawn its applications for services to Cairo and Khartoum. This is announced in the October 25 issue of Air Transport Licensing Board *Civil Aviation Licensing Notices*. In substitution of the withdrawn Far East applications, the company has applied for a cabotage service to Hong Kong *via* Aden, Gan and Singapore, to be operated with Britannias. This is expected to be heard by the Board during the second half of January.

Two of the withdrawn routes, London - Cairo - Luxor and London - Frankfurt - Rome - Benghazi - Cairo - Khartoum, were applied for in the first issue of the Board's *Notices*, published on January 11, 1961. As recently as September 20, British United asked for an amendment to the latter application to enable Viscounts and BAC One-Elevens to be used instead of Britannias and VC10s, so the change of policy is a recent one. There has evidently been a reappraisal of the potential traffic, mainly inclusive-tour, which does not appear to justify the services concerned. A scheduled service to Khartoum is in any case operated by British United on behalf of Sudan Airways, who recently increased frequency to twice-weekly.

Of greater significance is British United's decision to withdraw its original bid for routes to the Far East. Two applications, published in the Board's *Notice No 4* dated February 1, 1961, sought two licences, one for a service from London terminating in Tokyo, and the other terminating in Singapore. Originally "optional" stops were asked for at Istanbul, Teheran, Karachi, Bombay, Delhi, Calcutta, Bangkok and (in the case of the Tokyo route) Singapore and Hong Kong. The aircraft to be used were specified as DC-6s or Britannias initially and VC10s later, the services to be in effect for an indefinite period starting "as soon as possible."

British United's decision to moderate its Far Eastern aspirations suggests that it sees no hope of breaking the tripartite Air-India/Qantas/BOAC pool agreement, which specifies that BOAC shall be the only British carrier on the routes concerned. It seems strange that British United should have decided not to test the validity of this most conspiratorial of all state airline monopolies.

British United's order for four VC10s was based partly on the granting of Far Eastern route licences. Now that the applications for these have been withdrawn (the substitute licences do not specify the use of VC10s, but only Britannias) it must be supposed that British United will now reappraise also part of its VC10 order.

NORTH-SOUTH FLIES ON

ASSURANCES about the future of North-South Airlines of Leeds/Bradford were forthcoming last week. The share capital has been purchased by a group of private individuals, whose names could not be revealed as *Flight* went to press, and new directors have been appointed. The company's capital is to be increased, and a second DC-3 is being purchased. This will enable the company (which has a Bristol Freighter also) to mount a service, for which it has recently been awarded a licence, to Copenhagen—it is hoped within two or three months' time. The seasonal scheduled services operated during the summer linking Leeds/

**Civil Aviation (Licensing) Regulations 1960, Regulation 10(3)(c).*

AIR COMMERCE...

A regular frequenter of British airports these days is the DC-4 operated by Trans Atlantic Airlines, the US independent which has been operating this aircraft and a C-46 from Gatwick since early this year

Bradford with Exeter, Hurn and the Isle of Wight will be resumed next summer. There will, *Flight* is informed, be no staff redundancy as a result of the present changes in the financial structure and management of the company.

The name of North-South has for some time been linked with the Handley Page Herald, an order for one having been placed and a deposit of £5,000, believed to be non-recoverable, paid. The company hopes eventually to use Heralds for all its operations.

PEGASUS LAYS OFF STAFF

THE drop in traffic in winter months, to which little publicity is given with regard to the independents, was highlighted last week by the announcement that between 50 and 60 aircrew and ground staff of Pegasus Airlines Ltd, at the company's bases at Blackpool and Gatwick, had been given a week's notice.

Pegasus, which operates three Vikings, was formed in 1958 and is operated under the name of Claydon Aviation Ltd by Mr C. Claydon, a Luton builder. According to Mr Claydon the reason for the airline's demise is purely lack of business. "We don't have any business between now and Easter and we cannot afford to keep the dismissed staff on. After all, we are in business—not a charity organization." A skeleton staff will be retained during the winter.

There is no suggestion that Pegasus's air operator's certificate has been withdrawn. According to Mr Claydon, "The reason for our closing down is because the situation is completely untenable at the moment for the smaller operators." Only one licence submitted was approved by the ATLB for a scheduled service between Blackpool and Gatwick which was operated four times a week by the airline, which also operated charter services throughout the summer.

Mr Claydon is reported to have stated that he intends to carry on the firm, but will only hire out the aircraft.

VC10 WEIGHS IN

LATEST information on the VC10 family is that a development of the standard (as distinct from the Super) VC10 is proposed with a maximum take-off weight increased from 299,000lb to 310,000lb. This is half-way between the standard VC10 and the revised Super VC10 at 322,000lb; the latter has not changed since it was recorded in *Flight*'s June 8 issue as having superseded the original Super VC10s with lengths of 186ft and later 196ft 6in.

It will be recalled that the Boeing 707-320 and the intercontinental DC-8 both underwent a similar gross weight increase to the VC10 which, in its proposed 310,000lb version, shows improved payload/range capabilities. The range with maximum payload, in still air, at optimum cruise, no fuel allowances for reserves is 4,550 n.m. for the standard VC10 and 4,630 n.m. for the 310,000lb version. The range with maximum fuel in still air, at optimum cruise and no reserves is 5,620 n.m. with a 13,400lb payload for the standard VC10 and 5,460 n.m. with 24,100lb for the super.

SAFETY AND PUBLIC ACCOUNTABILITY

TWO events of some significance in the field of British air safety took place last week. One was the Ministry's confirmation that the air operator's certificate of Falcon Airways had been withdrawn; the second was the publication by the Flight Safety Committee of a new and improved Flight Safety *Focus*.

Withdrawal of Falcon's AOC This event took place on September 21, but no announcement was made at the time by the Ministry. It was not until October 25, when Falcon's managing director, Capt M. Kozubski, denied that his company was to cease operating, that any statement was made by the Ministry, who said that the Director of Aviation Safety took this action on September 21 "as a result of the running down of the company's operations in this country." On the same day Falcon Airways, said the statement, notified the Ministry of its intention to cease operations.

On October 25, however, a spokesman for Falcon said that operations had been suspended only during the coming winter months. "This is just a routine procedure," the spokesman added. "We did it last year." No staff were being dismissed, and Capt Kozubski actually spoke of possibly selling his two Constellations and buying Boeing 707s.

In the Commons on October 18 the new PPS to the Ministry of Aviation, Mr C. M. Woodhouse, said that air operators' certificates "can of course be, and in some cases have been, withdrawn." Asked what other AOCs had been withdrawn other than that of Falcon, the Ministry referred to one other, that of Overseas. Asked whether it was Ministry policy not to publish the withdrawal of AOCs in the future, as appeared to be the policy in the case of Overseas, a Ministry spokesman said that this would depend on the circumstances.

It will be recalled that Falcon Airways and Capt Kozubski were fined a total of £300 on September 6 for infringement of the Air Navigation Regulations (*Flight*, September 14, page 456). Capt Kozubski's joint managing director, Mr Frederick Beezley, resigned from the company on September 24.

Flight Safety Focus For those who have advocated the wider dissemination of safety information, the appearance of a new and enlarged issue of *Flight Safety Focus* is a most welcome event.

Focus has been published in bulletin form for private circulation to operators for 18 months. It is published by the Flight Safety Committee, a body independent of the Ministry comprising members drawn from operators, manufacturers, pilots, insurers and aviation authorities. Its objects are to collect and disseminate flight safety information, and to foster interest in the advancement of flight safety. *Focus* is the means of spreading knowledge acquired all over the world about accidents and incidents, and to spread it as widely as possible. Among the organizations which give financial support are the Air Ministry, Ministry of Aviation, ARB, BEA, BOAC, BIATA, the British Insurance Association, Lloyd's and the SBAC.

One medium for giving wider currency to the contents of *Focus* is, of course, the technical aviation press. Here the Flight Safety Committee ran into a problem. Safety is a subject in which everyone is interested, but which is at the same time extremely delicate. Thus, if a paper were to publish all the information that is included in the bulletin *Focus* without discretion, the work of the Flight Safety Committee, which depends on the co-operation of the aviation industry, might be inhibited. For example, an operator is not likely to tell the Flight Safety Committee of his experiences if he knows that it might appear in the press, and he be identified.

Focus is distributed to people in a position to take action in the field of aviation safety by the Secretary, Flight Safety Committee, Epsom Square, London Heathrow Airport, Hounslow, Middlesex. The first issue of *Focus* in its new and improved form contains much of interest. There is a note about the effects of correcting yaw in a big jet when engine failure occurs with the yaw damper engaged, emphasizing that it is good practice to turn off the yaw damper prior to making changes in rudder trim. There is a note about two cases reported when, on big jets, the elevator trimming actuator started to move of its own accord due to an electrical fault. There is also a note to the effect that it is always safer and less damaging to an aircraft to land on only two wheels following the malfunction of one, rather than to make a belly landing. Incidents involving fast rates of sink experienced by big jets approaching over blast fences are examined, and figures are given showing that there is an area of downward flow extending downwind beyond a blast fence; wind tunnel tests have indicated the hazard to aircraft on the approach of blast fences located near the threshold.

Other subjects covered are flag warning failures on VOR; interference to radio navigation equipment by passenger radios, the views of Col P. Stapp of the USAF on backward-facing seats and seat "g" standards; accidents involving failure of landing gear micro-switches and frozen undrained water altering elevator tab balance; and damage to cars caused by jet efflux during taxying. On the pilots' pet subject of "hear and be heard" the following advice is disseminated: "If you *don't* understand it, *have it repeated*. If you *do* understand it, *repeat it*. If you *don't* see it, say so. If you *do* see it, say so. Could be he doesn't see you."

The sources of the safety information given in *Focus* are given and each item is provided with an index classification for ease of reference.

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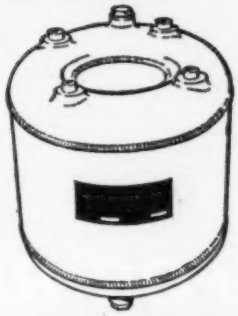

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A10

Originally F-BJTD of Air France, this Caravelle III of Air Liban, OD-ADY, is one of two bought for the Lebanese carrier by Air France. These two operate a twice-weekly Beirut - Rome - Paris service, and other routes in the Middle East radiating from Beirut

AIR COMMERCE...

Excess Capacity in Europe?

MONTHLY and quarterly statistics showing the trends in European air transport are compiled by the Air Research Bureau, but these short-term reviews do not give any clear indication of the long-term trends. Now, however, the "other ARB" have published figures showing the development of air traffic in Europe over the past five years.*

The statistics cover the 13 European carriers which are members of the ARB: Aer Lingus, Air France, Alitalia, BEA, BOAC, DLH, Finnair, Iberia, Icelandair, KLM, Sabena, SAS and Swissair.

Table 1: General Development of Intra-European Passenger Traffic—ARB Carriers

Year	seat-miles (million)	increase (per cent)	pass-miles (million)	increase (per cent)	load factor (per cent)
1956	3,700	—	2,200	—	59.9
1957	4,325	17	2,550	16	59.4
1958	4,950	15	2,725	7	55.4
1959	5,450	10	3,125	14	57.5
1960	6,500	19	3,700	19	57.3

The year 1960 can be regarded as successful from the point of view of passenger traffic growth, but the main problem is excess capacity. The position has never really recovered from the traffic recession of 1958, largely due to the wider use of large obsolescent piston equipment (e.g. DC-6Bs and DC-7Cs) and jets. Further substantial re-equipment with jets is taking place this year, and to quote from the ARB report: "The outlook for an improvement in the passenger load factor in the immediate future is not favourable." In 1960 jets provided 24 per cent of the total seat-miles produced on intra-European routes.

Table 2: Comparison Between Intra-European Traffic Growth and Development in Other Regions (1956 = 100) (based on passenger-miles)

	1956	1957	1958	1959	1960	Average annual increase (per cent)
ARB carriers:						
Intra-European	100	116	124	142	169	14
European domestic	100	120	127	145	175	15
Intercontinental and overseas	100	121	136	152	189	17
US carriers:						
International	100	112	117	135	159	12
Domestic-trunk	100	113	113	130	135	8
Local	100	118	130	162	180	15
Remaining world:	100	113	127	143	183	16

The European domestic figures above do not include statistics for non-ARB carriers, such as the British independents, Air Inter, Linjuflyg, etc. European domestic traffic would probably if these carriers were added have shown the highest rate of development of all the categories shown above. The outstanding fact emerging from the above table is the growth-rate of the intercontinental and overseas operations of ARB carriers. This averaged 17 per cent. Remarkable, too, is the relatively small average annual growth-rate of US domestic traffic; according to the ARB, this indicates the relative "maturity" of the US market while the European market is still in the "development" stage.

The average revenue rate has tended to reduce on intra-European routes, largely due to the extension of special fares—off-peak, night and excursion fares and inclusive tour rebates. This has been offset to a degree by the expansion of first-class traffic over the five years —from 7.7 per cent to 9.2 per cent of the total. The effect of the further expansion of economy fares on intercontinental routes is evident, as the revenue rate has fallen by 7 per cent in the past two years to 3.75 cents per passenger-kilometre, and by an average of 6.2 per cent over the five-year period. The average intercontinental revenue rate is now 15 per cent below the intra-European rate, which stands at 4.41—which in turn is 35 per cent higher than the domestic average of 2.90 cents.

* *Traffic and Operating Data, ARB Carriers 1956-1960. Air Research Bureau, 67 Rue de la Loi, Brussels. Price not quoted.*

Table 3: ARB Carriers—Intra-European Traffic

Year	Average stage distance per flight (miles)	Passenger trip length (miles)	"Hops" per passenger
1956	320	414	1.11
1957	328	435	1.13
1958	330	420	1.12
1959	333	430	1.17
1960	335	427	1.16

The passenger trip length and number of hops per passenger are calculated by dividing total passenger-kilometres and total sector passengers, respectively, by the number of "point-to-point" passengers. Since the number of passengers is the total number of flight coupons issued and passengers are often issued with more than one flight coupon for a journey, the figures for passenger trip length and hops per passenger shown above are probably on the conservative side.

Although the increase in the average stage distance per flight in 1960 was very small, over the five-year period the trend continues upwards; this in general should, if the trend continues, benefit operating costs. The continued growth of passenger traffic should eliminate some intermediate stops on multi-sector routes, and furthermore if these stops are minimized the high speed of jet aircraft could be more fully exploited.

The average number of seats per aircraft increased in 1960 by 5.6 to 58.9 whereas the figure for 1956 was 48.3. Average speed per aircraft hour has increased from the 1956 figure of 314km/hr (195 m.p.h.) to 367km/hr (230 m.p.h.) in 1960. Jet aircraft have been introduced progressively during 1960; these average between 72 and 84 seats each, and to a slightly lesser extent the introduction of Super Constellation and DC-7 equipment accounts for the large increase in seating. The increase in average speed of only 13 m.p.h. in 1960 would appear to be low considering that jet aircraft carried 24 per cent of the passenger traffic as against 4 per cent in the previous year. As the jets only flew 18 per cent of the total distance flown, however, the major portion was still flown by piston and turboprop equipment. The average speed should rise in the next few years.

Table 4: Percentage Distribution of ARB Carriers' Traffic (passenger-miles)

Year	Domestic	Intra-European	Intercontinental and overseas	Total
1956	11.8	30.4	57.8	100
1957	11.9	29.7	58.4	100
1958	11.4	28.8	59.8	100
1959	11.6	29.2	59.2	100
1960	11.4	28.4	60.2	100

In the above table "intercontinental" includes not only long-haul traffic but regional traffic carried outside Europe. The proportion of intercontinental and overseas traffic has increased, but variations between the three categories are not large.

Generally the rate of growth of freight traffic has been slow, although in 1959 and 1960 the increase was large by comparison —19 per cent in each case. Over the five-year period from 1956 to 1960 freight traffic has expanded at the same rate as passenger traffic. The smaller cargo capacity available on jet aircraft is evident from the small increase of only 4 per cent, whilst the operation of all-freight services has increased by over 50 per cent during the year. In 1960 some 24 per cent of all-freight traffic was carried on freighter aircraft compared with 19 per cent in the previous year, the expansion during the year therefore being largely on all-freight services.

The ARB forecasts that passenger-miles will increase in 1961 by 14 per cent to 4,250m, but that capacity seat-miles will increase by "at least" 20 per cent. The report confirms present-day fears by saying that "in 1961 the passenger load factor will fall by almost three percentage points to around 54.5 per cent."

Cunard Eagle Western

HOW A SMALL BRITISH INDEPENDENT FINDS LIFE IN HIGHLY COMPETITIVE US AIR TRANSPORT MARKETS

By the Air Transport Editor

EVERY year hundreds of thousands of Americans spend their holidays in the British Crown Colonies of Bermuda and the Bahamas. Year by year the business grows, and year by year more of it is carried by air. BOAC (and Pan American and other big US lines) have been in these markets for years; two or three years ago a British independent—with the moral support of the two Colonies—decided to participate. This is not a story of BOAC v Cunard Eagle, lively and unique though this corporation-independent rivalry has been. It is the story of a British independent that knows the meaning of the word competition.

ONE April Sunday morning three years ago I drove to Blackbushe to see an Eagle Airways Viscount 805 take off for Bermuda. I suppose I must have had a notion that the occasion was to prove historic, as I do not frequently drive 50 miles on a Sunday morning to see aeroplanes take off on ferry flights. We recorded the event, the birth of an enterprise which is the subject of this story, in *Flight* for April 25, 1958.

Just before the take-off I talked in the airport lounge with Mr Harold Bamberg, chairman and managing director of the Eagle companies. He was flying out in VR-BAX to launch a scheduled service by Eagle Airways (Bermuda) Ltd between the Colony and New York. He was, he said, in so many words, trying to find a way in which Eagle could break the shackles that restrained it at home—more so in those days than now.

The formation of a Bermudan company was a gamble—perhaps Mr Bamberg's boldest. A small independent does not lightly duplicate its commercial and operational overheads by setting up an entirely new establishment 3,000 miles from home, challenging the might of Pan American, Eastern and BOAC, and expect to get

ILLUSTRATED WITH "FLIGHT" PICTURES

rich quickly. That Sunday morning take-off three years ago has not yet paid off in terms of £ s d. But it has paid off in other ways.

Suppose that *Flight*, in recording that take-off, had attempted to forecast its direct consequences. Could we have predicted that, within three and a half years, Eagle would have the name of Britain's premier transatlantic shipping line, Cunard, in front of it, and Cunard's resources and influence behind it? That Eagle would have been granted an application to operate a London - New York service in competition with BOAC? That it would have placed a firm order for two Boeing 707s? That it would, within two and a half years, be operating a scheduled Britannia service between London and Miami? That it would be offering more seats on the Nassau - Miami route alone than on all its European scheduled routes put together? And that it would have grown into an expatriate British airline steeped in the thrusting commercial expertise of American air transport? No one could have predicted all that.

Two impressions stand out most strongly from a tour I recently made, at Cunard Eagle's invitation, of the airline's western hemisphere division, comprising Cunard Eagle Airways (Bermuda) Ltd and Cunard Eagle Airways (Bahamas) Ltd. One was the reputation and wide currency in this hemisphere of the name Cunard; the other was the invigorating American idiom in which this British airline handles its selling and marketing.

First, the name Cunard. The adverse current trading results of this company, and its full-astern manœuvres on Q.3, are symptoms of radical change throughout the shipping industry. But it is not likely that the 190-year reputation of the name Cunard will ever lose its lustre. Imagine walking into St Peter's in the

The company's two 50-seat Viscount 755s link Bermuda with New York (one or two daily roundtrips) and Nassau with Miami (four daily)

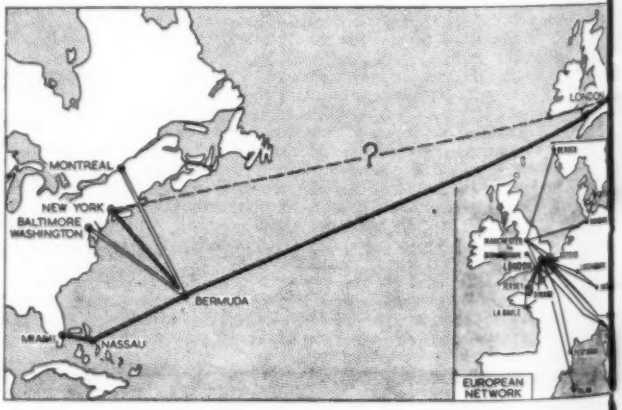
Vatican and being told: "This is our reservations department." Irreverent though this would be, you can nevertheless walk into the reservations department of Cunard's home at 25 Broadway in downtown New York and find yourself comparing its spacious expanses of marble, tapestried vaulting and soaring dome with the splendours of St Peter's. I have never seen a place of business like it.

"This," explained Mr M. A. Guinane, chief executive of Cunard Eagle's western hemisphere division, "is our reservations department." He took me along marbled corridors to meet Mr W. Daly, Cunard's manager in the USA, an engaging North Country character who has lived for 40 years in America, and in whose person is embodied all that the name Cunard means to Eagle in that country.

The "cathedral," as I subsequently learned it is known to the staff, is but a part of Cunard's stately home in New York. It began to dawn on me, as I walked from one mahogany-panelled stateroom to another, that Cunard is not just a British company with an office in New York. It is part of the Establishment of American business—and so, by adoption, is Cunard Eagle. On the day of my visit, Noël Coward's new musical *Sail Away* opened on Broadway. It is written around the Cunard ship *Caronia*, whose owners, as members of the American Establishment, contributed $10,000 to the show's production. I had lunch with Mr Daly at the India Club, a sort of New York Athenaeum—solid, respectable and traditional. On entering and leaving you have to pat the belly of a bronze Buddha in the lobby; I never found out why. It is frequented by the elder statesmen of American commerce, the men who run the American economy.

Mr Daly seemed to know everyone, and everyone seemed to know him. "I hear you're going to take all our West Indies cruise business this year," he said to the distinguished president of an American shipping line as we were leaving. "Every bit of it," replied his fellow club member, "every darned bit of it. But we feel real affection for you, Bill, real affection." Banter between competitors, of course. But it was meant in the spirit which prompted an American *Caronia* passenger to write in a letter received by Mr Daly on the day of my visit: "While there may be several good and reliable steamship lines, there is only one Cunard."

The name provides Eagle with something more than a highly respected brand image, important though this is to the airline's sales. The frustration of often being asked "Who's Eagle?" by American travel agents and the public vanished when, in March 1960, the name Cunard was appended. Today, the parent shipping company is always there to give practical help and moral



Cunard Eagle's mid-Atlantic service, London - Bermuda - Nassau - Miami, is operated by Britannias under the Bermuda flag, and is the axis of the airline's western-hemisphere and European services. Addition of the North Atlantic route, logical next link between the airline's operations in America and Europe, at present awaits the outcome of the BOAC appeal and the award of a US foreign carrier permit

At Miami, third busiest US airport, there are 58 Cunard Eagle movements a week. These comprise the frequent Viscount shuttles to Nassau, and the weekly Britannia service from London. Taking off is an Eastern Air Lines Boeing 720

support. The airline's main offices are in the Cunard building in New York; and Mr Guinane, the chief executive, is warm in his choice of words about the help he and his staff have been given.

The relationship appears to be one of mutual respect and independence; the parent does not meddle in the airline's affairs.

The two top men, both exceptionally agreeable people, are Mr M. A. Guinane, chief executive (based in New York), and Mr H. P. Snelling, general manager, who is based in Bermuda. Mr Guinane was a pilot with Eagle in its earliest days, later forming his own airline, Dragon Airways. Until he was given the job last year of running Cunard Eagle's western hemisphere division, he was Mr Bamberg's deputy in London. He is respected for his flair for management and administration, one of his specialities being cost control (he calls for a report each month from every department, comparing actual expenditure with the budget, and wants a good explanation of any actual that is above estimate). Mr Snelling joined the company last spring, having for many years been commercial manager of Skyways in London. He holds the operational and commercial reins in the two Crown Colonies which are, so to speak, the mother countries of Cunard Eagle's western hemisphere division. It was Mr Snelling, for example, who brought about the recent signing of what he described to me as a "pact of non-aggression" with the new Bahamas Airways on the Nassau - Florida route (about which more in another article).

At Bermuda one of the company's two Britannia 318s passes through on the weekly mid-Atlantic scheduled service from London to Nassau and Miami. These aircraft have 98 seats—14 first-class, 66 economy and 18 Skycoach (the latter to the Colonies only). During the recent summer Cunard Eagle's Britannias operated 75 transatlantic one-way charters, and the airline's four DC-6s operated a further 40

Mr Daly, naturally enough, has pretty strong views about air v sea transport on the North Atlantic. I asked him about the extent to which Cunard might wish to influence the commercial and fares policies of its airline when (no one says "if") Cunard Eagle gets into business on the North Atlantic. His reply was: "The best way we can help Cunard Eagle is to sell it." He reminded me that there are 15 Cunard offices in the USA, and nine in Canada, and that their sales staff have undertaken courses with Cunard Eagle in the techniques of airline sales and reservations.

The best way Cunard can help, said Mr Daly, is by selling Cunard Eagle—and Cunard are doing this already with a sales organization unmatched by any foreign airline operating into the USA.

While the name Cunard has given renewed power and thrust to the airline, this big British shipping line's investment in air transport is one that must pay off. This summer's season on the North Atlantic has, if anything, been worse for the shipping lines than it has for the airlines; the controversial Government assistance for a new £30m *Queen* may not now, after all, materialize; and passenger, mail and cargo traffic between Europe and the USA will inexorably continue to be lost to the air. Sir John Brocklebank, the Cunard chairman, has said that the "extent of Cunard's investment in air transport and its relation with Cunard's shipping interests will be the subject of close examination." To put it bluntly, Cunard Eagle must get its North Atlantic licence. If it does not, the Cunard-Cunard Eagle partnership is bound to be in jeopardy.

My second strongest impression—the American air transport accent of this British independent—registered again and again during my tour. It registered most strongly during talks I had in New York with Mr Alfred M. Hudson, general sales manager, and Mr Bob Garrity, interline and agency sales manager. Both are Americans (indeed, except for the chief executive and his Bermuda-based deputy, Mr H. Snelling, the airline's commercial staff is predominantly American or American-schooled).

Talks with them strengthened my belief that Cunard Eagle knows, more than any other British independent, the meaning of competition. The airline flies Viscounts between New York and Bermuda in competition with 707s and DC-8s operated by Pan American, the world's most powerful international airline; with the DC-8s and DC-7s of Eastern, the second biggest airline in the world; and with the 707s and Britannias of BOAC, an airline whose reputation for service and aggressive selling is—I was pleased to hear—acknowledged wholeheartedly by Cunard Eagle. And on the Nassau - Miami route, the airline's Viscounts are up against Pan American and BOAC's Bahamas Airways. How does this company, which has no cosy pool agreements with anyone and which has only a small fleet, a small staff and a small budget, survive?

Not only has the lamb survived among the lions; it has steadily increased its share of the market on both routes. The table below tells the story of the New York - Bermuda route.

These results speak for themselves. The results on Nassau - Miami are, if anything, more impressive. My questions to Messrs Hudson and Garrity were aimed at trying to discover how such results are achieved by a small airline in the face of massive competition, and on routes where there are no predetermined restrictions on the amount of capacity that anyone can schedule.

"There is as much competition on the New York - Bermuda route," said Mr Hudson, "as on any route in air transport." He remarked that when Eagle first went in, "everyone said we hadn't a hope. We went in and fought, and Pan American, Eastern and BOAC fought harder. This develops the business for everyone."

I asked what sort of competition BOAC put up. "They're not dragging their feet," was the reply, "they provide a real good service." Did Cunard Eagle, in its sales efforts, find that BOAC, so to speak, was always there before? "Sometimes, oh yes, they're there before us," Mr Hudson said, "but other times we're there before them. And we're not short of ideas. Although we couldn't be closer or better friends with John Fountain [BOAC's manager in Bermuda], between 9 and 5 we're out to capture every bit of the market. He respects us and we him."

I asked Mr Hudson whether he believed that if you put a new carrier on a route it increases the market. "It has to," he replied. "New men, new ideas—they develop the market for everyone. On the Atlantic route you have PanAm with 23 per cent of the market, TWA with 13 per cent, and BOAC with 10 per cent.

NEW YORK - BERMUDA COMPETITION

Airline	1958			1959			1960			1961 (January to August)		
	Passengers	l.f. (%)	Market (%)	Passengers	l.f. (%)	Market (%)	Passengers	l.f. (%)	Market (%)	Passengers	l.f. (%)	Market (%)
PAA	74,393	68.9	47.6	71,555	62.1	46.2	75,005	70.9	45.3	57,341	65.8	48.2
BOAC	30,718	70.2	19.6	37,046	64.5	23.9	36,381	59.6	21.7	23,329	44.9	19.6
EAL	41,046	42.9	26.5	30,842	44.5	20.1	34,656	52.3	20.8	20,530	45.8	17.4
CEA	9,977	48.4	6.3	15,207	54.9	9.8	19,806	68.8	12.2	17,598	51.8	14.8
Totals	156,134			154,650			165,848			118,798		

Note 1: Provision of seats during the 1961 summer peak was: PAA, 28.3 per cent; BOAC, 31.8 per cent; EAL, 25.2 per cent; CEA, 14.7 per cent. **Note 2:** Flights operated during the 1961 summer peak were: PAA, daily Boeing 707 plus two weekend extras; BOAC, daily Boeing 707 plus daily Britannia; EAL, daily DC-8 plus three weekend Super Constellations; CEA, daily Viscount plus two/three Britannias per week.

Cunard Eagle Western . . .

Left, chief executive of Cunard Eagle's western hemisphere division is Mr M. A. Guinane, based in New York. Right, general manager for Bermuda and the Bahamas, and Mr Guinane's deputy, is Mr H. P. Snelling, based in Bermuda

It only stands to reason that another British carrier would help to capture a bigger British share. The people that travel with BOAC will continue to travel with BOAC. I would say that non-British airlines are carrying a proportion of the potential British market. About 70 per cent of the US-UK market is comprised of US citizens, and we intend to develop that market."

These remarks typify, one might say, the airline's broad strategic approach to business. What about the tactics that actually get the results?

The Viscounts have 2 by 2 seating; this unique competitive feature is made the most of in all promotional material. There is a propeller discount fare of $95 on the New York - Bermuda route, applicable if New York departures are after 9 p.m. The airline has made the most of this by catchily promoting its services as Sunset Flights. Similarly, the airline's early morning discount-fare services on the Nassau - Miami route, when they applied, were called Early Bird flights. In the UK such fares would be called "off-peak night tourist," or something; catchy names like Sunset or Early Bird can do much to alleviate the confusion which promotional-fare structures create.

The airline believes strongly, small though its staff is, in maintaining close personal contacts with pamphlet-choked travel agents. It puts out pamphlets too, but tries to make them refreshingly unusual without being gimmicky. Personal contacts are maintained with the top twelve US travel agents and package tour wholesalers —in particular with the three who produce 60 per cent of the Bermuda business—Thomas Cook, American Express, and Haleys. The company's sales people also believe in trying to gain the respect of agents by always giving them the whole picture.

For example, when a new promotional New York - Bermuda eight-day excursion fare was introduced, Cunard Eagle sent a letter to agents explaining its *general* applicability, and not just its applicability to CEA. The respect of one recipient at least was gained. One of the largest hotel corporations in America took the trouble to write: "Congratulations on an excellent piece of public relations and a good push for Cunard Eagle. Your letter unquestionably eliminates confusion in the various mailings by the various airlines. Considering the way some have printed their air fares I am surprised anybody gets to Bermuda!"

Other examples of CEA commercial tactics are worth recording. "We will always take the time to help," said Mr Garrity, "even if there's nothing in an enquiry for us." Again, Cunard Eagle got the agreement of Bermuda hotels to give visitors arriving after 10 p.m. on stays of seven days or more complimentary first night accommodation. Pursuing those many Americans who like to go to Bermuda for golfing holidays, the airline "got a corner on this market" by offering to carry golf bags at the nominal rate of $2 a time. The competition followed suit, and the IATA rate is now $4 for everyone, but as Mr Hudson remarked, "golfers still think of us as the promoters of golfing holidays." About 15 per cent of the traffic to Bermuda is comprised of honeymoon couples, offering the airline a special opportunity—it gets a laugh—for promotion of 2 by 2 seating in its Viscounts. Cunard Eagle was, I was told, the first to promote the air/sea market between New York and Bermuda, in an effort to tap new surface-travelling business. Having been on board the *Queen of Bermuda* (now in the UK for a refit and a single-funnel mod) I can appreciate the appeal to Americans of gracious, spacious sea travel.

Mr Hudson said: "We try to do the unusual within the confines of the regulations. With a small company, a small fleet, a small staff and a small budget you can't afford to scatter your buckshot." Thus, last year, the services from Bermuda to Montreal and Washington were temporarily suspended to enable concentration of sales effort on New York. About 80 per cent of the air business to Bermuda comes from within 300 miles of New York City; of this 60 per cent comes from the three main travel agents, and 20 per cent from interline sales. The A1 Hudsons and Bob Garritys of Cunard Eagle are great believers in market research, an activity —unusual in small airlines with limited staff—which Mr Hudson describes as "extremely important."

I was shown by Mr Garrity a map of the USA showing, state by state, whence and in what numbers all US - Bermuda traffic originates. New York generated by far the most in 1960—32,281, followed by Mass with 10,758, and New Jersey with 10,459. (Idaho produced eight.) This map was cross-referenced with tables comparing one year with another. One whole day each week is spent by Mr Hudson in analysing the sources of the previous week's sales results, by looking at US Passport office figures, interline sales, agency sales, and the reservations department's reports.

At a later stage in my tour, in Miami, I got the impression that not all the airline's promotional ideas are monopolized by the sales people in New York. When Cunard Eagle's mid-Atlantic service from London to Bermuda and Nassau was extended to Miami, Cunard Eagle's man in that remarkable city, Mr William Kinnear, an American, got hold of a London bus from somewhere and had it driven round Florida for two weeks with two stewardesses on board to promote this new US gateway to London and Europe. The response was tremendous; yards of press cuttings, dozens of civic receptions, and 26 radio and 14 TV broadcasts. The tour cost $3,500, but sales of 104 London - Miami tickets (at more than $400 a time) were pinpointed as having directly resulted from the trip. When the tour was proposed some people thought that the idea was corny, and not altogether consonant with the dignity of the Cunard name. But, as Mr Kinnear remarked to me, "it netted x dollars and y cents." And, as somebody else added, aren't there fruit machines on board the *Queen Elizabeth*?

About £95,000 a year is spent on promotion in CEA's western hemisphere markets. This budget covers advertising, publicity, leaflets, counter cards, etc. The company employs an American advertising agent. I asked Mr Hudson the relative productivity of the media in which the airline concentrates its advertising buckshot. First, he said, newspapers, particularly the *New York Times* travel section. Certain magazines are, he feels, as productive as newspapers—*New Yorker*, *Sports Illustrated*, *Holiday*, *Time*, for example. TV is "extremely important," but so expensive in New York that "everyone has looked twice at it."

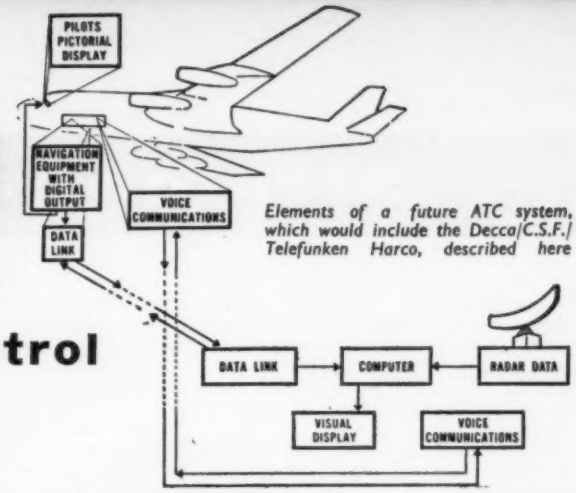
A sum of £95,000 a year is not much to have available for promotion, a lot of money though it may be in Cunard Eagle's western hemisphere budget. It doesn't get the airline as well known as Pan American; as Mr Garrity said, babies are born saying "Pan American." But, thoughtfully spent, it all helps; and anyway, there must be some of Cunard's competitors who would say that babies are born saying "Cunard."

[*In the course of half a dozen flights with Cunard Eagle the author saw for himself the end-product of the commercial effort. We hope to record his impressions in a later issue.*]

They came to a city—view of America's most fabulous holiday resort, Miami Beach, as seen from the flight deck of a morning Viscount service (Capt Vivian Robinson) from Nassau

FLIGHT SYSTEM SURVEY

Harco and Eurocontrol



Elements of a future ATC system, which would include the Decca/C.S.F./ Telefunken Harco, described here

MOMENTOUS developments for the whole field of civil aircraft navigation were announced last week by the Decca Navigator Co. As briefly reported on pages 648-660 last week, a consortium composed of Decca Navigator in Britain, C.S.F. in France and Telefunken in Germany are developing a new navigation system based on Decca Navigator and called Harco (Hyperbolic ARea COverage). Thus not only the design and sales, but also the name of equipment based on Decca, is now international. Most important of all, Eurocontrol is to evaluate Harco as a standard navaid to supersede VOR/DMET.

During 1959 the technical group of Eurocontrol considered available navaids to meet the ATC requirement for the upper airspace. They rejected the NDBs and decided that VOR/DME was inadequate; and they drew up a specification which was distributed in April 1961 to the electronic industries of the European countries. The provisional target was for an aid which could be provided by 1965. The French Radio Mailles and developed Cossor Gee were submitted and rejected. Very recently S.T.C., L.M.T. and Lorenz submitted a VOR/DMET scheme and an American company suggested MOPTAR. Assessment of these two systems was left to the FAA. Inevitably, Eurocontrol findings on Harco will be closely examined by the FAA and by ICAO.

The Eurocontrol operational specification mainly requires maximum coverage, including sea areas, at minimum cost; high diversity of use among all categories of aircraft; area coverage to permit any desired route structure and to facilitate changes without costly re-deployment of ground stations; simplicity of interpretation and use of airborne equipment; integration with automatic techniques into the ATC system by automatic data links without loss of basic accuracy; great reliability; compatibility with the long-range navigation systems; high accuracy, particularly for terminal area; low-altitude cover for helicopters and light aircraft. The specification also called for a 95 per cent probability of a track-keeping accuracy of ± 2 n.m. with a position accuracy of not less than ± 1.5 n.m. Coverage was to extend from ground level to 80,000ft. Pictorial presentation was to be provided in the cockpit to facilitate ATC procedures in terminal areas and position information was to be continuous.

The New International Aid

Harco, based on Decca principles, will effectively cover this specification. Chains already located in the Eurocontrol countries, with the addition of three new chains in France and one in West Germany, will provide an accuracy not worse than 0.25 n.m. by day and 1.5 n.m. by night along the worst direction of the error ellipse. For Harco, all the chains will have to be slightly modified by the provision of a central synchronous clock, but this will not affect the operation of existing airborne Decca. On the airborne side, computers and display systems range from a relatively simple and unsophisticated display for light and slow aircraft to an automatic, self-setting presentation with push-button operation and utilizing conformal charting. Full Harco capability is based on a revolutionary new miniaturization of the Decca receiver now being developed by C.S.F. in France. The red, purple and green receivers are reported to measure about 9in by 1in by 1in each. They are fully transistorized and are being designed for a mean time to failure of 1,000hr. Telefunken are working on the presentation and on the two-way data link described below. Decca are contributing patent rights for their existing equipment and have now completed trials of the Self-setting Flight Log and Omnitrac computer. The full Harco equipment now presents itself as follows. Decometers and associated manipulation are entirely eliminated and the three small C.S.F. receivers feed Decca signals directly into the Omnitrac computer. This will contain a small core memory which will control the sequence of 19 multiplications, 14 additions, one division and one square root, plus the retention of seven intermediate results required in the process of converting Decca hyperbolic co-ordinates to Cartesian co-ordinates once every 0.6 sec. The resultant stream of newly calculated positions would be fed directly to the photo-electric sensers which will position the pen on the chart by means of the black-and-white digital tracks along one edge of the chart and an equivalent mechanism behind the pen. The pen itself now consists of a mechanical pecker stippling a track on the reverse side of the chart through a typewriter ribbon. The chart itself is no longer held in a cassette but simply wound on a spool much like a film in a camera. Almost 40ft of chart can be carried. Additional digital tracks between the various charts on a strip will automatically programme the computer to the appropriate scale and the divergence of the chart axis from axis of the Cartesian grid, which is aligned with True North. Operation of Harco therefore requires the pilot only to switch the system on and, by pressing appropriate buttons, align the computer-setting digital tracks of the appropriate chart beneath the photo-electric element. Harco, incidentally, involves no loss of accuracy relative to Decca Mark 8 and avoids manual setting errors.

Decca envisage a duplicate Harco installation in which the first pilot would have a receiver, Omnitrac and Self-setting Flight Log, while the second pilot would have a plain Flight Log backed by a Mk 10 receiver. Another part of the basic Harco navigational system is a "Ghost Buoy" facility based on the Cartesian grid of Omnitrac. The crew will be able to select range and bearing to any geographical point up to 256 miles distant.

In their Valetta on Monday of last week Decca demonstrated the Self-setting Flight Log Mk 3 and Omnitrac computer with range-and-bearing facility. Omnitrac was the original prototype, occupying about 1 ATR case size and containing a memory drum turning at 12,000 r.p.m. No exotic electronic techniques have been employed and components are in all cases of-the-shelf items. The Self-setting Flight Log can be arranged in many ways and Decca have suggested a version which is mounted flat in the glare shield and can be tilted vertical when in use. Half-million scale charting was being used, showing some 40 n.m. either side of the track without any distortion. The flight from Gatwick led over Mayfield, down and up the Amber airways across the south coast and back via Mayfield. Range and bearing to successive reporting points were continuously shown—an eerie sensation, because the information was not being derived from any beacon. Two chart-changes involved only 12sec interval each and the pen moved itself to the new position. Way points for range and bearing signals would normally be selected by turret switch or punched card. The prototype Omnitrac has run for 1,200hr with only two faults.

As important as the basic navigating function of Harco will be the additional capacity inherent in the system for ATC purposes. Omnitrac will, for instance, be able to operate from air data, Doppler or inertial systems to provide navigation information with or without Decca. Automatic chart-changing may be provided. Optical sensers in conjunction with the pictorial display could allow autopilot coupling for following curved as well as straight tracks. Finally, the digital output could be fed into a two-way VHF data link transmitting position, height and identity to an ATC computer without loss of basic navigational accuracy. The scanning rate of the data link would be of the order of ten aircraft per second per channel and the sequence of automatic interrogation could be varied by the controller as required. Required position or track could be fed back to the aircraft from the ground and the autopilot coupling might eventually be actuated by such instructions. It might also be possible to combine the position information with height, so defining a three-dimensional track either as a notification from the aircraft or as an instruction from the ground. Ultimately, the information derived from the data link could be used to feed synthetic radar displays.

Eurocontrol evaluation will involve flying by French aircraft and possibly the co-operation of A. and A.E.E. Boscombe Down. The distribution of sales at present envisaged is that C.S.F. will sell the receiver and Telefunken the presentation and data link within the Common Market. Decca would produce and sell the equipment elsewhere and would also receive the licence royalties. But Decca intend to allow manufacture virtually anywhere in the world; they have already secured the co-operation of Teleregister Corporation, a major American company specializing in on-line data processing and systems design. Bendix, Decca's present US representatives, will concentrate on military applications.

Straight and Level

A PRICELESS collector's piece for connoisseurs of air transport lunacy was seen at London Gatwick Airport last week. It was an Antonov An-12, complete with rear gun turret, in the markings of Ghana Airways.

This airline, I am told, made a loss last year of £6m. Of course, the Ghana Government has said that Ghana Airways is essentially an instrument of prestige. It has therefore bought for its status symbol six Il-18s, two Britannias, three Viscounts, three VC10s and a number of An-12s. Two Boeing 707s were also ordered, although these were cancelled as an economy measure.

* * *

BOAC manages Ghana Airways, and understandably won't talk about its affairs. But I should imagine that it has warned the Ghana Government about the staggering cost—especially for an undeveloped new nation—of the policies it is pursuing. I hope so, because when the day of reckoning comes the BOAC staff could well be dismissed on the pretext that it was they who were responsible for the losses.

The An-12 that was seen at Gatwick was the embodiment of Ghana's lunatic obsession with air transport as an instrument of prestige. This is, of course, a common form of lunacy, nationalism being the reason why international air transport economics are as imperfect as they are.

In fairness, the An-12 was not as priceless a collector's piece as it might have been, as there appeared to be no guns installed. Perhaps the empty turret will be used, for a surcharge of course, as an observation lounge. No doubt if guns are installed on regular services, this will be in furtherance of a policy of "if you can't beat 'em, shoot 'em."

● A copy of *Airframe*, the monthly newspaper of the British Aircraft Corporation, was drawn to my attention by my chief attention-drawer last week. This paper can be bought for 2d a time by employees of the various BAC companies—Vickers, Bristol, Hunting, English Electric. The front-page lead story was headlined "BAC One-Eleven Breaks Into Dollar Market," and it was all about the Braniff order for 12 One-Elevens.

The date of the issue was Friday, October 20—the day on which this news was published in the national papers. Thus BAC's personnel had the news in their own newspaper on the day it was released to the world.

Not, perhaps, an event of shattering importance. But it will have earned respect for a works newspaper which—like all other works newspapers—is an important instrument of personnel relations, corporate unification and all that.

● In a recent issue of *The Birmingham Post* a news item about Braniff's order for BAC One-Elevens carried the headline: US TO BUY BRITISH AIRLINERS.

Next to this headline was another—relating to quite a different news item—bearing the headline: HEIR FOR VISCOUNT.

● At a news conference in London last week the Minister of Planes, Mr Hugh Strangeways, announced that no fewer than 14 small British independent airlines had been forced out of business during the previous week. He was, he said, delighted at the results of his campaign to "wipe all small British airlines off the face of the earth." He added that he was intending to introduce new legislation which would "make it impossible for even the most determined and enterprising small British airline company to remain in business for more than five minutes."

The Minister dismissed recent suggestions that the death penalty should be introduced to deter the managements of small airlines from introducing low fares, and suggestions that life imprisonment should be the penalty for such offences as the achievement of low operating costs, the innovation of fresh ideas, personal service, specialized work for charterers, membership of the Baltic Exchange, and so on. Such measures, he said, would be "unduly restrictive"—though they might have to be applied if matters got out of hand.

He was hoping, he said, looking at his watch, that another 32 small independents would be forced out of business during the next 24 hours.

● The uplifting influence of Flight Falsies Ltd is becoming apparent in the light-aircraft field. I quote a panegyric on a certain accomplished aeronautical scribe printed in the current issue of the Swiss *Private Pilot Magazine*:

"[He] thinks the fast, low-wing business plane is hard to beat for enjoyment today, but he prefers something like the Aviamilano Falso 'because you can really put it through the hoop'."

I don't know whether the Chance Vought engineer above has ever actually met Miss Linda Bromley (left) of New Rochelle, NY. At any rate, he is being restrained from his forward lunge by a 60g "restraint system"; she is modelling a "personalized fall-out detector." Thus do man and woman go forward together into the future

● We all make mistakes, journalists no less than anyone else. But not many of us could drop four clangers in a 180-word article about aviation, as *Topic*, the new weekly news magazine, did in its second issue.

International air traffic has *not* been "taking a low dive" in 1961. The British Aircraft Corporation is *not* comprised of de Havilland, Hawker-Siddeley (with or without the hyphen) and Vickers. The de Havilland Trident is *not* a twin-jet. And the BAC One-Eleven is *not* written BAC III.

I don't want to be a nitpicker, or should it be a *Topick*picker (see this column last week), because it's easy to make mistakes when things have to be rushed to press. But four per 180 words is quite a clanger-rate.

● "A Lockheed Six Shooter aircraft crashed in woodland at Denham, Buckinghamshire, last night . . ."

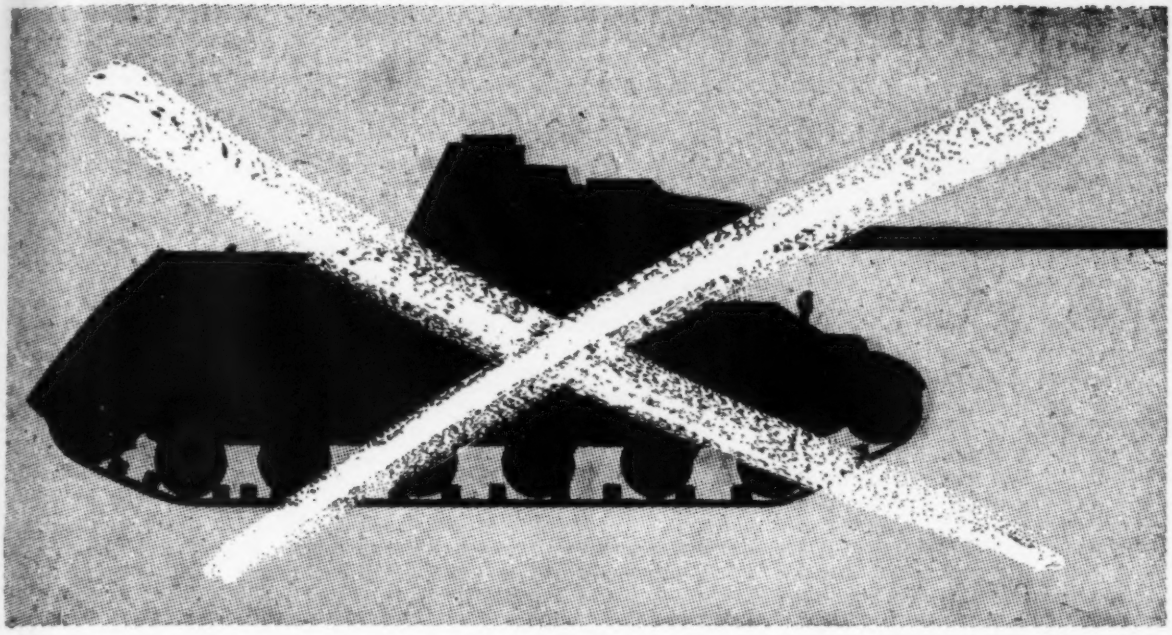
The Guardian

A Piper Colt, perhaps?

A.I. . . ?

● "Four Gannets, which early morning radar had rendered pregnant, flew over with one turboprop stationary."—From *Motor Sport*.

ROGER BACON



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482

LIVES SAVED TO DATE BY MARTIN-BAKER EJECTION SEATS

M·B·A

A Westland Belvedere of 66 Sqn in Germany during Exercise Spearpoint, which marked the type's first operational appearance on the Continent (last week, page 648)

SERVICE AVIATION

Air Force, Naval and Army Flying News

Bomber Command Change

AN exchange of senior posts in Bomber Command has been announced. AVM M. H. Dwyer, CB, CBE, who has been AOC No 3 Group since May 1959, is to become Air Officer-in-Charge of Administration at Bomber Command headquarters; he is being succeeded as AOC No 3 Group by AVM B. K. Burnett, CB, DFC, AFC, who has been AOA since January 1959.

Air-minded Army

WEAPONS and equipment the British Army already operates, and some it would like to have, were on show last week at the Fighting Vehicles Research and Development Establishment, Chertsey, Surrey. The occasion was a demonstration called "Argus," planned by the Master of the Ordnance, Lt Gen Sir John Cowley, and opened by the Secretary of State for War, Mr John Profumo, who arrived in proper style by Army Air Corps Alouette, which brought him from Battersea Heliport. "Proper" because much of the emphasis in this demonstration was on airborne or aerodynamic equipment: missiles, aircraft, parachute loads, and an air-supported stretcher carrier.

Missiles like Blue Water, Thunderbird, Honest John, Vigilant and Malkara, which showed their portability in a drivepast and were on static show, are already in service or are to enter it; detailed reference is made to them elsewhere in this special issue. Of the aircraft being demonstrated—Alouette, Scout, Belvedere and Wessex helicopters; Rotodyne; Beaver, Caribou and Herald—only the Scout is really a newcomer. In the airborne sphere, when it comes to troop-carrying and supply-dropping, the Army depends wholly on co-operation with the RAF through 38 Group of Transport Command. Load-carrying was exemplified in the full-scale Short Belfast skeleton fuselage mock-up (which is to stay at FVRDE for loading trials), showing the disposition of a 79,000lb payload of Army vehicles; and in various forms of stressed platforms and containers. The air-cushioned stretcher carrier, developed by Folland Aircraft, was described in *Flight* for May 11 this year.

From the evidence of "Argus," the Army is becoming more and more an air-minded force, as Transport Command gradually gets the sort of aircraft—particularly with the introduction of Argosies (this page, last week)—needed to carry it, and as it puts more faith in missiles (though big tanks like the Chieftain, which made its debut in "Argus," are still lumbering into existence). Increased use, too, is being made of radar, like E.M.I.'s Green Archer, which locates enemy mortars.

Pilots of Flying Training Command who recently flew four Hunting Jet Provost T.Mk 51s to Khartoum for delivery to the Sudan Air Force. Leading the flight was Flt Lt David McCann, deputy leader of the CFS aerobatic team (with map); the others are Flt Lt H. W. J. Rigg and Fg Off R. M. Austin from No 1 FTS, and Flt Lts C. N. P. Thorman and B. I. Hamilton and M Plt H. F. Shepherd from No 2 FTS

RAF in Lord Mayor's Show

AT this year's Lord Mayor's Show, a week on Saturday (November 11), the stage is being held by the RAF and they are sparing no effort to take advantage of this opportunity. An advance Air Ministry description says that "on 21 floats built specially for the occasion, the Royal Air Force will present a pageant depicting major aspects of its training and operations, and something of its social and recreational sides"; and again, "aided by flood-lighting and animation, the half-mile-long pageant will depict Air Force life from the youngsters of the Air Training Corps and the apprentices and boy entrants to the deterrent aspects of the V-bomber and guided missile forces." All eight RAF Commands at home have contributed; and in addition to the procession of floats there will be a flying demonstration over the river, Whirlwinds and Sycamores of Transport Command taking off from Battersea Heliport. Men of the RAF Regiment will jump from Whirlwinds into barges, a Belvedere will lower supplies, and winch rescue techniques are to be demonstrated.

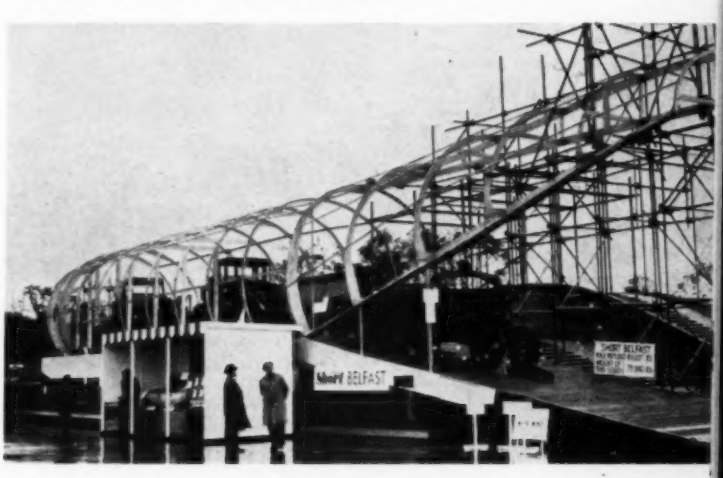
Air Commodore Posts

TWO air commodore postings have been announced. Air Cdre H. N. G. Wheeler, CBE, DSO, DFC, AFC, who has been taking this year's Imperial Defence College course, is to become Air Member of the Defence Research Policy Staff next January; and Air Cdre P. C. Fletcher, OBE, DFC, AFC, formerly Deputy Director of Joint Plans at the Ministry of Defence, has become Director of Operational Requirements (B) at Air Ministry. Air Cdre Wheeler flew with 207 Sqn early in the last war, then with a PR unit, and subsequently commanded a Mosquito squadron, No 236. Air Cdre Fletcher, a South African, won the DFC when serving with 258 Sqn during Japanese attacks on Ceylon.

IN BRIEF

The twelfth annual reunion of Fleet Air Arm and RAF personnel who trained at USNAS Pensacola, Fla, USA, is being held in London on November 25. Details from Sqn Ldr L. V. Armstrong, 47 Rutland Road, Wanstead, London E11.

The Whirlwind crews from Leconfield who took off the crew of the boom defence ship *Barmouth* received congratulations from the Royal Navy last week. The Flag Officer Scotland, Rear Admiral A. R. Hezlet, sent a signal to the RAF paying tribute to the "skilful airmanship and courage in appalling weather that resulted in the successful rescue of the *Barmouth* crew."



Short Belfast freighter mock-up at the Fighting Vehicles Research and Development Establishment, Chertsey, showing distribution of a 79,340lb payload (see "Air-minded Army," col 1)

"Flight" photograph

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. Names and addresses of writers, not for publication in detail, must in all cases accompany letters.

Airline Regularity

REFERRING to the letter from Mr A. M. Blakemore in your Correspondence columns on October 5, I think it is important before making any judgment with regard to regularity that we know precisely what basic definitions are being applied in the computation of the relevant statistics.

The Air Research Bureau, through a sub-committee composed of the statistical experts of our member airlines (which covers pretty well the major European scheduled operators), has been circulating statistics with regard to regularity and punctuality for the past twelve months and at the very outset it was therefore necessary to agree on basic principles and definitions. The first principle we established was that regularity and punctuality ratios should be a measurement of the standard of the product manufactured in relation to that advertised, i.e., performance of the airline in relation to the published schedule.

With regard to regularity, this should be a measurement of the relationship between the number of services advertised in the timetables and the number of services completed. In accordance with our principles, we do not count a service which is cancelled because there is no load as a service not completed; on the other hand, we regard a service which is diverted from its advertised destination as incomplete.

The question of punctuality is also important as a measurement of the standard of service offered by airlines to the travelling public. What is a punctual service? We consider that this is a flight which arrives at its destination within 15 minutes of the advertised time.

An overall average of punctuality can be a highly misleading statistic for the purpose of comparison between airlines, as punctuality depends upon a great number of factors, including (a) route length and number of intermediate stops; (b) type of equipment operated; (c) length of time this equipment has been in operation; (d) region in which the services are operated and the prevailing weather conditions.

I would therefore make the point that the regularity figure of 98.1 for BOAC, 97.2 for BEA and 99.7 for the Independents only goes to show that *all* are offering a good standard of service to the public as regards the operation of flights according to schedules. The differences between the figures are of small consequence and one cannot draw comparisons between them without knowing the statistical background.

Brussels 4 R. E. ALCOCK,
Chief Research Executive, Air Research Bureau

Napier Spraymat Licensees

IN your issue of October 19, on page 627, you imply that Pacific Airmotive Corporation—who are our Spraymat licensees in the USA—are supplying Spraymat equipment for the F-104G in Europe.

We would like to make the position regarding our licensees quite clear. Pacific Airmotive (Flight Support) are licensees for the production and sale of Spraymat equipment in the USA only. We also have the following licensees:

France: Bronzavia, 207 Boulevard Saint-Denis, Courbevoie (Seine)—for the manufacture and sale of Spraymat in France.
Germany: Westfalische Metall Industrie KG (Hueck & Co), Lippstadt—for the manufacture and sale of Spraymat in Western Germany.
Japan: Shin Mitsubishi Heavy-Industries, Reorganized, Ltd, No 10, 2-Chome, Marunouchi, Shiyoda-Ku, Tokyo—for the manufacture and sale of Spraymat in Japan.

Westfalische Metall Industrie are responsible for the F-104 Spraymat system in Germany and have been assisted in the interim period of the formation of their plant at Lippstadt by Flight Support in the supply of prefabricated intake heater mats.

Luton, Beds C. L. COWDREY,
General Manager, D. Napier & Son Ltd

Results of a Vintage Aircraft Search

FOR some time past, as mentioned in a letter which you published in *Flight* on June 1 this year, I have been trying to start an air museum in the West Country. After many months of rather wearying effort, I can now report on the progress made, mainly concerned with the types I am trying to save.

With the help of the Australian Government, I have traced the last Walrus. Found in a poor state by a Captain Gibbes of Ansett/ANA, it was stripped down and rebuilt by him and some friends. Now it is in service, giving joy-rides, and registered as VH-ALP.

Sunderland ML824 on show (see letter from Mr Peter F. M. Thomas)

Although I am writing to Capt Gibbes, I doubt whether he will be willing to part with this veteran, even when it becomes grounded.

The Eire Government own the last Martinet, the only survivor of the Master series. I am now negotiating with them for the purchase of this aircraft.

An Oxford (G-ALTP) has been acquired by the Hampshire Aeroplane Club, and has been given the RAeS plaque awarded to historic aircraft.

The Australian Government assure me they have no Beaufighters left, in spite of persistent reports to the contrary. I am now investigating reports concerning one at Luqa, Malta, although with little hope of finding that they have any substance. I am also approaching the Israeli Government about Beaufighters.

There are more than sixty Dragon Rapides still on the British Register. This information, supplied to me by de Havilland, really surprised me. I am now looking for one that can be acquired for preservation.

I am told that the Tempest 2 at the College of Aeronautics, Cranfield, is to be scrapped. I have written asking that it should be saved, as I will give it a home.

The enclosed photographs [one is reproduced above—Ed] show our Sunderland, ML824, when on view earlier this year. The aircraft is still being prepared for permanent preservation and will be on view to the public next year, on a full-time basis.

Pantgwyn Mansion, Cardigan PETER F. M. THOMAS

Astrorelativity ?

YOUR second report of the IAF Congress in Washington (*Flight*, October 19) made interesting reading, particularly as it appeared to include an account of two speeches made (a) three days after the Congress ended, and (b) in New York, not Washington. For Mr Owen's information, New York is the place with the UN building and terrible weather; while Washington is the one with the Washington monument and terrible weather.

Was this an exercise in astrorelativity, with time and place indiscriminately confused, or was American Rocket Society hospitality such that Mr Owen saw the UN building and believed it to be the Washington monument?

St Albans, Herts M. REID FOSTER

[Kenneth Owen writes: "Thank you, Mr Reid Foster. American Rocket Society hospitality was good, but not that good. My October 10 piece reporting the words of Mr Frutkin and Prof Van Allen was in fact datelined New York, but was accidentally transposed with the October 9 instalment by my friends and colleagues back home in Dorset House, London, England."—Ed.]

FORTHCOMING EVENTS

Nov 3 RAeS Rotorcraft Section: "Electronic Flight Information Displays for the Rotary-wing Aircraft," by Wg Cdr J. C. G. Bell.
Nov 9 Radar and Electronics Association: "Space Communications" (Part 2), "Orbits and Their Economics," by W. F. Hilton.
Nov 10 British Interplanetary Society: "Photography from Rockets and Satellites," by R. Hall.
Nov 14 RAeS Astronautics and Guided Flight Section: "A Comparison of the Control Problems of Missiles and Aircraft," by K. W. Smith.
Nov 15 Royal United Service Institution: "Amphibious Warfare in the Late 1960s: Seaborne/Airborne Operations," by Maj-Gen J. L. Moulton.
Nov 16 RAeS: Seventeenth British Commonwealth Lecture, "The Progress of BEA and of European Air Transport 1946-61," by Lord Douglas of Kirtleside.
Nov 17 RAeS Man-powered Aircraft Group: "Aerodynamics of Man-powered Aircraft," by T. R. F. Nonweiler.
Nov 17 Institute of Navigation: "The Navigation and Guidance of Supersonic Aircraft," by Capt William L. Polhemus.
Nov 21 RAeS: "Military Ground Effect Vehicles," by W. H. Coulthard.
Nov 22 RAeS Graduates' and Students' Section: "Army Aviation," by Col C. D. S. Kennedy.
Nov 22 British Interplanetary Society: Symposium on "Materials for Space Technology."
Nov 23 RAeS: "Flight Characteristics of the B-58," by B. A. Erickson.
Nov 24 RAeS Graduates' and Students' Section: Winter Dance.
Nov 27 RAeS Historical Group: "The Society's Library and Aeronautical History," by F. H. Smith.
Nov 28 Institute of Transport (West Middlesex Group): "A Pilot's View of Air Transport," by Capt O. P. Jones.
Nov 29 Society of Environmental Engineers: "The Response of Dynamic Systems to Shock Excitation," by B. H. Venning.
Nov 30 Guild of Air Pilots and Air Navigators: Professional Licence Holders Meeting; Annual Service and a.g.m.

RAeS Branch Fixtures (to Nov 9): Nov 3, *Brough*, Annual Dinner-Dance; *Glasgow*, Symposium on "Engine Production"; Nov 6, *Boscombe Down*, "Investment Castings for the Aircraft Industry," by W. O. Beer; *Derby*, Sixth Sir Henry Royce Memorial Lecture, "Civil Aviation—a Forward Appraisal," by P. G. Masefield; Nov 8, *Brough*, Eighth Sir George Cayley Memorial Lecture, "The Aero Engine in the Twentieth Century," by Air Cdre F. R. Banks; *London Airport*, "The Scientific Investigation of Aircraft Accidents," by Dr P. B. Walker; Nov 9, *Bristol*, Film Evening.

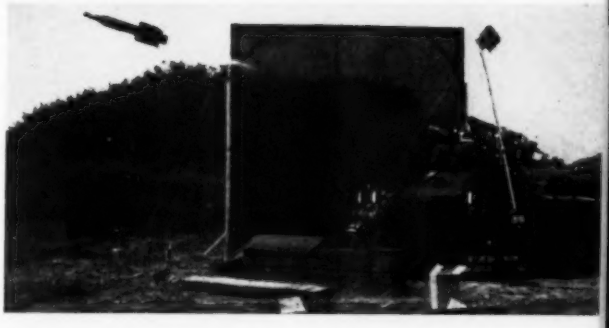
Three Bullpup B missiles carried by a Douglas A4D-2N of the US Navy

Right, Hawks of the US Army on their launcher loader near Schweinfurt

MISSILES 1961

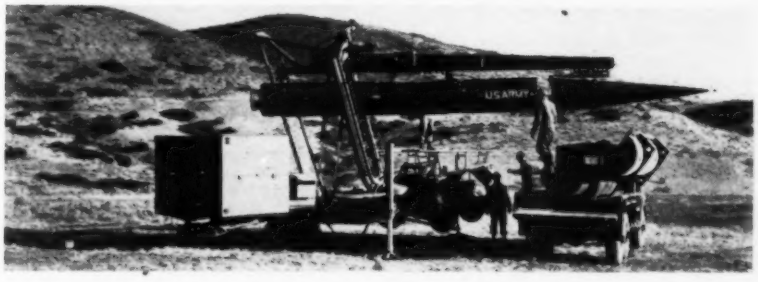
IN THE FOLLOWING 25 PAGES will be found the Technical Editor's survey of the world's missiles for 1961. This is the sixth of these reviews, its predecessors having been published on December 7, 1956; December 6, 1957; December 5, 1958; November 6, 1959; and November 4, 1960. These dates are given because many of the descriptions in the following pages allude to earlier and lengthier appraisals. In preparing the earliest reviews the author was accustomed to spend weeks on end analysing official statements, unofficial reports and even such unlikely sources as journals on mathematics and advertisements for electronic equipment. A careful process of distillation ensued, but, even so, the final offering was liberally sprinkled with suppositions and uncertain deductions. Several of the objects under scrutiny were, in any case, not weapons but test vehicles. This year one of the principal difficulties has been to select words and phrases capable of describing multi-million-dollar weapon systems in ten or a dozen lines. Information today is available for the asking. It is merely necessary to conduct a mild exercise in filtration and to turn out an appropriate length of text. This "appropriate length" varies enormously, and, in the first section which follows, such missiles as Atlas, Minuteman, Polaris and Titan are each accorded the dignity of a small book.

Above, a frame from a cine film of a recent Bloodhound development firing

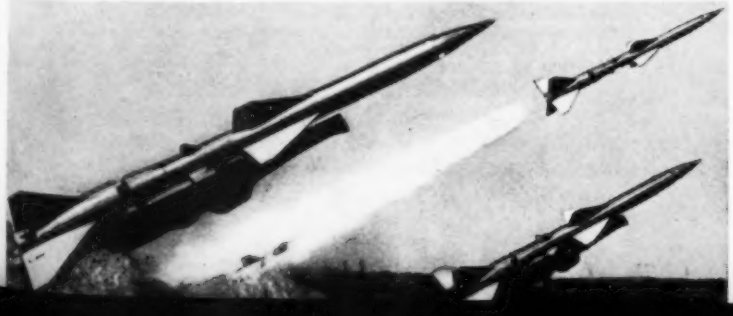


Right, Vigilant fired from Ferret scout car of the Royal Armoured Corps

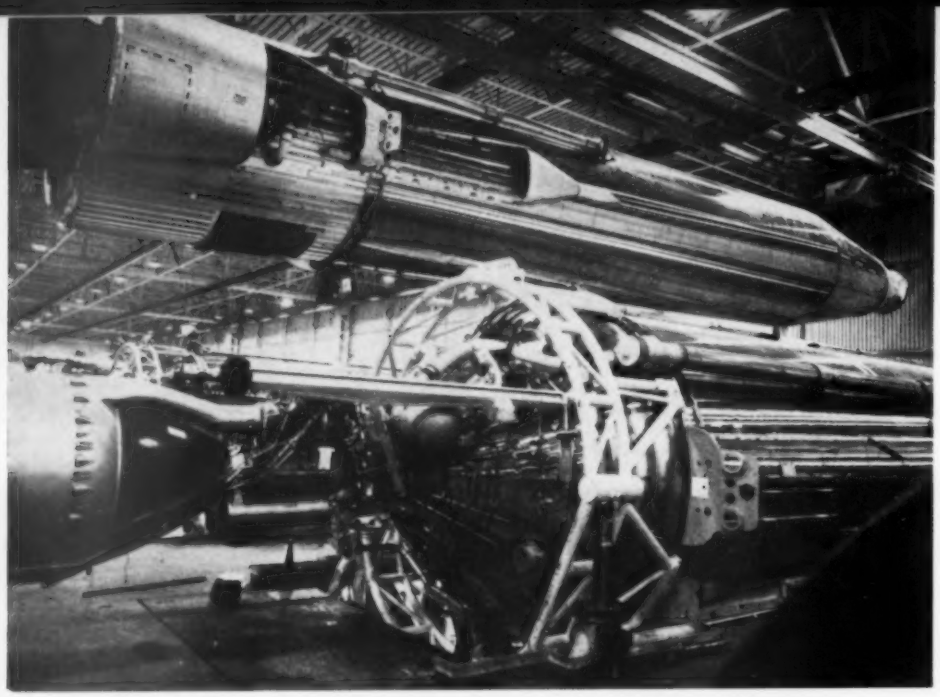
Below, a US Army crew of six assemble their Sergeant during field trials



This Soviet anti-aircraft missile can be launched at a shallow angle



Genie being loaded aboard F-106A



E-model Atlas ICBMs for Strategic Air Command in the San Diego plant of General Dynamics/Astronautics

Strategic Missiles

Propellant abbreviations used in the tables in the following pages are: LO_2, liquid oxygen; K, kerosine; PBAA, polybutadiene acrylic acid; PU, polyurethane; RFNA, red fuming nitric acid; HTP, high-test peroxide; RP-1, wide-cut paraffin; N_2O_4, nitrogen tetroxide; JP-4, gas turbine wide-cut fuel; UDMH, unsymmetrical dimethyl hydrazine; H, hydrazine; AP, ammonium perchlorate

ATLAS

ICBM for deployment from fixed, soft, semi-hard and hard bases

US AIR FORCE (*Weapon System 107A-1, Strategic Missile 65*)

FOR the third year running, we can open our review with the words "Outside the Soviet Union, the USAF Weapon System 107A-1, of which the Atlas missile forms a part, is the only ICBM system to have reached the operational stage." Three complete bases have reached initial operational capability, and a fourth base, bringing the total number of missiles up to 51, is scheduled to become operational in nine weeks' time, as described later in this account.

It was in October 1945 that the Air Force invited industry to submit proposals for research and development of a missile with a range of 5,000 miles. By early January of the following year engineers at the Vultee Field Division of Convair, at Downey, Cal, had roughed out two possible designs, one a pilotless bomber and the other a supersonic rocket-powered ballistic missile. A study contract awarded in April 1946 paid for Project MX-774, a ballistic test vehicle which introduced such important innovations as swivelling engines for trajectory control, a thin-wall pressurized airframe, and a separable nosecone. Three examples were actually fired in 1948, but defence economies forced the USAF to shelve the idea of an ICBM (intercontinental ballistic missile).

Convair continued limited research with their own funds, and the outbreak of fighting in Korea prompted the Air Force to award the MX-1593 study contract early in 1951. This called for an assessment of intercontinental ballistic and glide rockets, and in September 1951 Convair proposed an ICBM incorporating the three design-features tested on MX-774. Eventually an *ad hoc* committee of the Air Force Scientific Advisory Board concurred with these proposals, and in 1953 (when Convair became a division of General Dynamics) it was clear that the project was feasible and could be accelerated.

In 1954 the Strategic Missiles Evaluation Committee recommended maximum acceleration of the programme, and a full go-ahead for WS-107A-1 was ordered in January 1955. In September the project was put on a "crash" basis, and fabrication of airframes began in the company's plant at San Diego. Extensive static-testing facilities were constructed throughout California and at Cape Canaveral, and steps were taken to establish a separate Astronautics operating division at a large new plant north of San Diego.

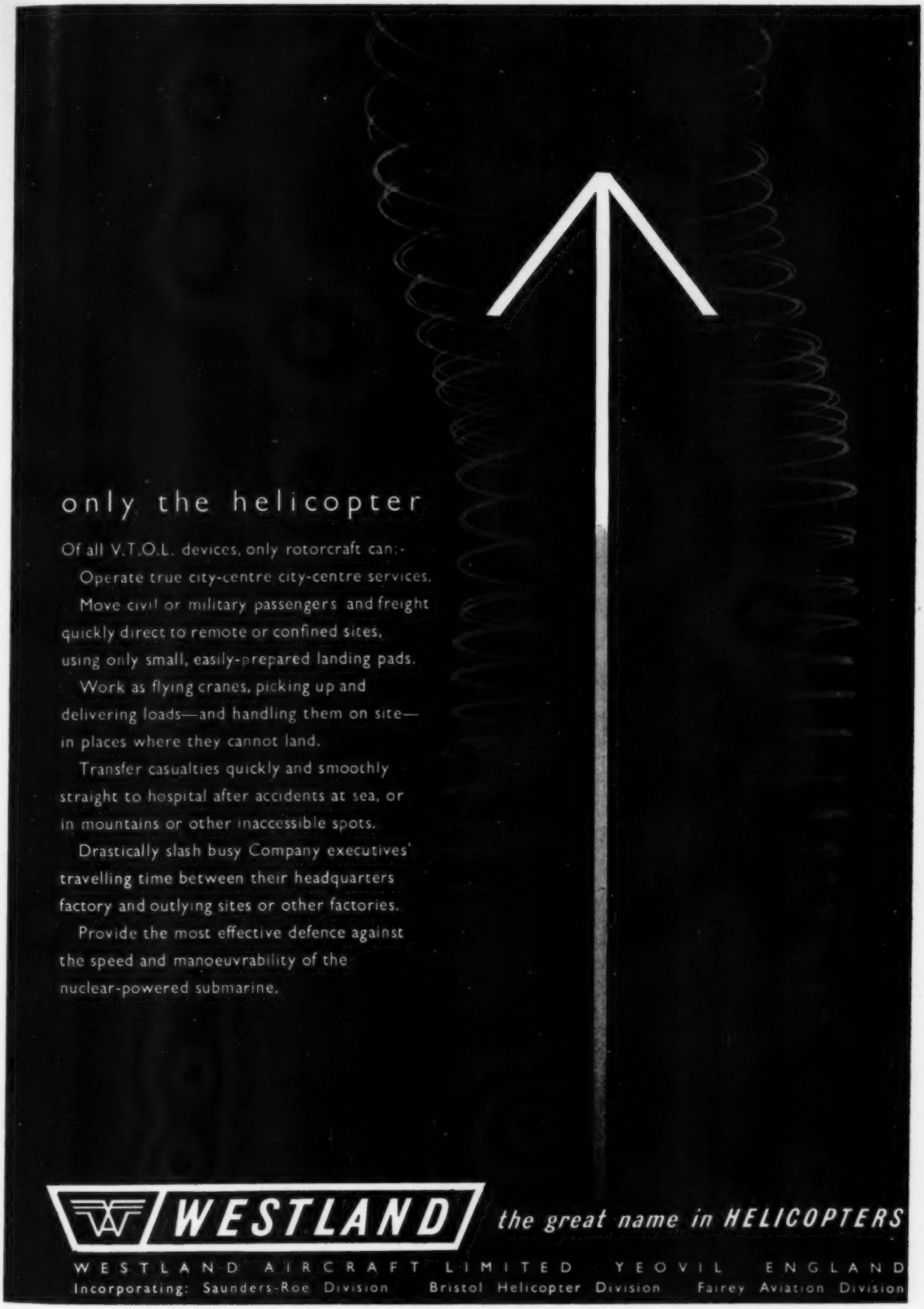
Propulsion-system and component tests started in June 1956, and the first static and flight-test missiles were completed later the same year. The first flight took place from Cape Canaveral on June 1, 1957, when missile 4-A was destroyed by the range safety officer after withstanding violent manœuvres following failure of one booster engine. Missile 6-A achieved more test objectives on September 25, and a fully successful flight was achieved by 12-A on December 17, 1957.

During 1959 Atlas Series C and D test missiles were in production, and between July 21 of that year and March 8, 1960, logged a run of 21 consecutive successful flights. By this time Astronautics and the Air Force had embarked upon the enormous project of constructing Atlas bases throughout the US. It was appreciated that, although steady improvements could be made in both the basic design and detail engineering of the emplacement, the principle of concurrence demanded that base construction proceed in parallel with missile development. This has inevitably meant that the first bases are obsolescent, and of limited value, and it also means that overall programme cost is increased. But if the principle had not been followed, not one Atlas would today be operational.

Details of the bases are given a little later in this account. More than 9,000 of the 27,000 Astronautics employees are working away from San Diego, the majority being assigned to base activation. Up to 3,000 people are directly employed on the construction of each base, and at least 2m persons are involved in the overall Atlas-base programme.

It is appropriate now to describe the missile itself. Atlas is unique in being a "one-and-a-half stage" vehicle, all engines being ignited before liftoff and the boosters being jettisoned about two minutes later. The tank sections are fabricated by precision-welding thin sheets of special stainless steel, with a very close tolerance in thickness. When completed, the tank is pressurized to a differential of about 9.8lb/sq in to maintain stability.

To the lower end of the RP-1 fuel tank is attached a monocoque skirt section, stiffened by external stringers, which encloses the complete propulsion system until jettisoned at booster cutoff. The engines fitted comprise: a sustainer on the centreline with a sea-level rating of approximately 57,000lb; two jettisonable booster engines, one on either side of the sustainer, each with a sea-level rating of 165,000lb (150,000lb in Atlas Series A, B, C and D); and two vernier engines, each rated at approximately 1,000lb, attached to the sides of the fuel tank. All five engines are made by Rocketdyne, are gimbal-mounted and are ignited before liftoff. After some 120sec of flight the Atlas is turned from vertical to an angle of approximately 70 , and the boosters are jettisoned. The sustainer is shut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off approximately 4min 30sec after launch, and when the velocity is correct for the mission the verniers are also cut off.

Guidance was originally to have been of a radio/inertial type, but in 1958 this was exchanged for the pure-inertial system developed by American Bosch Arma for the Titan. The airborne portion of the system is packaged in the lateral fairings along each side of the missile, together with the autopilot, telemetry transmitters, propellant-utilization computer, range-safety system and tracking transponders.

All ICBMs for the US Air Force have to be capable of delivering any of the re-entry vehicles developed for such weapons. The first Atlas test missiles were fitted with the General Electric Mk 2 heat-sink nosecone, of the type fitted to the Thor (*q.v.*). The operational re-entry vehicle for Atlas, also developed by GE, is the slender Mk 3, with an ablative covering. This is appreciably lighter than the Mk 2 cone, and has very much reduced drag and better stability within the atmosphere. As a result, payload, impact velocity and accuracy are all substantially increased. Atlas has also flown with the Avco Mk 4, designed for Titan.

Probably more than 200 Atlas missiles have now been delivered from the General Dynamics/Astronautics plant, and a total of 97 have been launched. Of these 97 vehicles, ten were unsuccessful, 21 partially successful and 66 fully successful. These launches included 16 scientific experiments, 12 of which were rated successful; included in these non-military shots were several with second stages added, details being given at the end of this account.

Delivery of Atlas D missiles with initial operational capability started in 1959, and the first batches were sent to the Strategic Air Command 1st Missile Division at Vandenberg AFB, California. This is not primarily an operational ICBM base, but is the indoctrination and training headquarters for all such weapons. Each type of ICBM has a training squadron at Vandenberg; that for the Atlas is the 576th Strategic Missile Squadron, who first fired a missile (No.12-D) from Vandenberg on September 9, 1959. Since that date 17 additional Atlases have been fired by the 576th SMS from Vandenberg, two of the latest firings having been of the more powerful E models.

It is the latter which equips all the US Air Force ICBM bases which have so far become operational. Chronologically the first of these bases is Warren AFB, near Cheyenne, Wyoming. This is a non-standard launch complex. Owing to its early design it has suffered from the gradual evolution of both the missile and its method of deployment, and it accordingly houses three squadrons, each of which differs from its neighbours. The 564th SMS occupy six "soft" (above-ground-level) emplacements, with end-sliding roofs, arranged in a single group with minimum spacing. The 565th SMS occupy three complexes, each containing three missiles in soft emplacements with split roofs sliding sideways, thus slightly reducing the reaction time (the time taken to fire following an order to do so). The 549th SMS have nine missiles, each in an individually isolated semi-hard (recessed into the ground) installation in which the missile lies horizontally below ground level until erection.

Initial operational capability at Warren was achieved during 1960, and nearly all the 24 launchers have now been checked out, accepted and loaded. The second base became operational on October 4: Fairchild AFB, near Spokane, Washington, with nine semi-hard missiles arranged individually like those of the 549th SMS, and a "toughened" microwave communication system able to withstand an overpressure of 25lb/sq in. The third base was accepted as operational on October 16: Forbes AFB, Topeka, Kansas, with similarly emplaced missiles. Early next year work should be completed at Offutt AFB, Omaha, Nebraska (the headquarters of Strategic Air Command), which will have three flights each of three Atlas E missiles.

Soviet prowess in the field of nuclear delivery systems was so rapid that in 1959 the decision was taken to develop a fully hardened Atlas installation. After intensive research, the design was completed of an underground silo in which a single missile could be housed, loaded and then elevated to the surface before firing. Efforts were made to find a method of firing the missile from the bottom of the silo, but the problems posed by such schemes were severe.

A simple sketch of the silo appeared on page 707 of our issue of November 4 last. Owing to the fact that the missile is carried on top of a flame-deflector bucket mounted on a large crib, the silo is even larger than those dug for the longer Titan missile, the depth being 174ft and the diameter 52ft. The launch-control centre is hardened some 100ft away, being connected to the fifth-floor level of the silo by a tunnel. Full protection is given against radiation, and the resilience of the crib suspension guards the missile against severe earth shocks from near-misses.

In the main silo are housed the hydraulic power systems which open the steel and concrete doors and elevate the missile, together with the propellant storage tanks, counterweights, servicing platforms and a wide range of support systems. The missile can be stored with the RP-1 fuel tank filled, but the liquid oxygen must be pumped in immediately after the decision to fire is taken (and before elevation to the surface).

Designation of the missile tailored to these silos is Atlas Series F. Incorporating the uprated booster engines of the E, and a variety of additional improvements, further design changes were necessary to permit the Atlas F to be launched by squadrons normally equipped with the Series E. Among the features of Atlas F are the following: addition of unspecified special fuel equipment in the booster and sustainer fuel-feed lines, upstream of the main valves, to permit long-term storage with the system filled; addition of a draining device to remove possible impurities which accumulate at the bottom of the fuel tank during long-term storage; addition of special fuel-loading equipment to permit the missile to be launched from the horizontal emplacements designed for Atlas E; addition of extra helium storage spheres for tank-pressurization during an accelerated countdown; and minor modification to the electrical power harnesses.

The first of the new series to be launched was missile 2-F, which flew a successful 5,000 n.m. mission down the Atlantic Missile Range on August 8. This mission provided an impact-point test to a designated target near Ascension Island, and also obtained environmental data for use in the design of advanced ballistic vehicles and confirmed the Series F ground-support system.

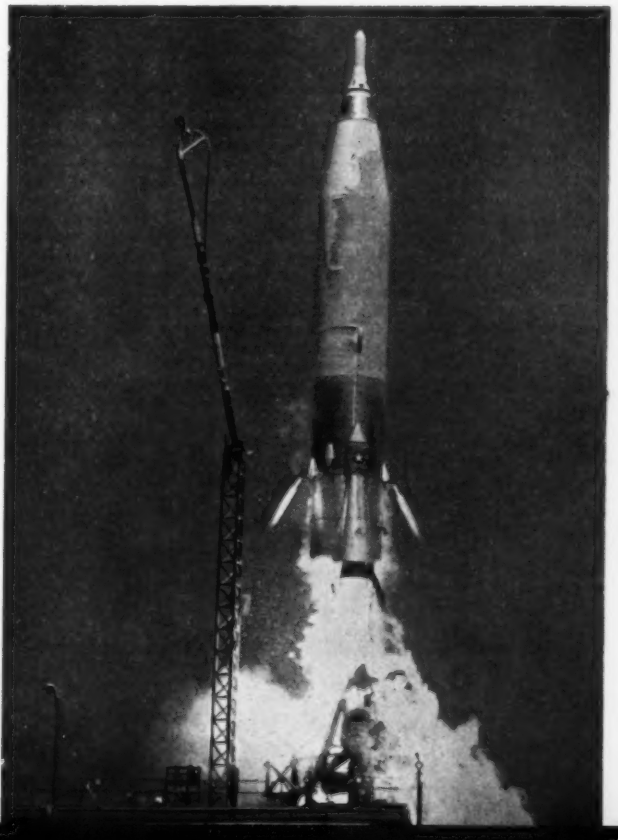
Silos for Atlas F missiles are being constructed at Lincoln AFB, Nebraska, which will have nine missiles, and at: Walker AFB, Roswell, New Mexico; Dyess AFB, Abilene, Texas; Altus AFB, Oklahoma; and Plattsburgh AFB, New York, each of which will house a squadron of 12 missiles.

Atlas has already served as the first stage of such important space programmes as Mercury, Midas and Samos. This great vehicle is scheduled to launch more than 100 additional space payloads during the remainder of this decade. Outstanding among these future programmes are Mariner, Ranger, OAO and OGO (all with Agena B second stage), and deep-space Mariner, Surveyor, Arents and Advent (using the Centaur second stage).

FRENCH IRBM

SINCE 1958 the French Government has been sponsoring the development of an IRBM to assist the Mirage IV in delivering the French independent deterrent. The programme is being managed by the *ad hoc* consortium

Launch of Atlas 56-D on 9,000-mile flight



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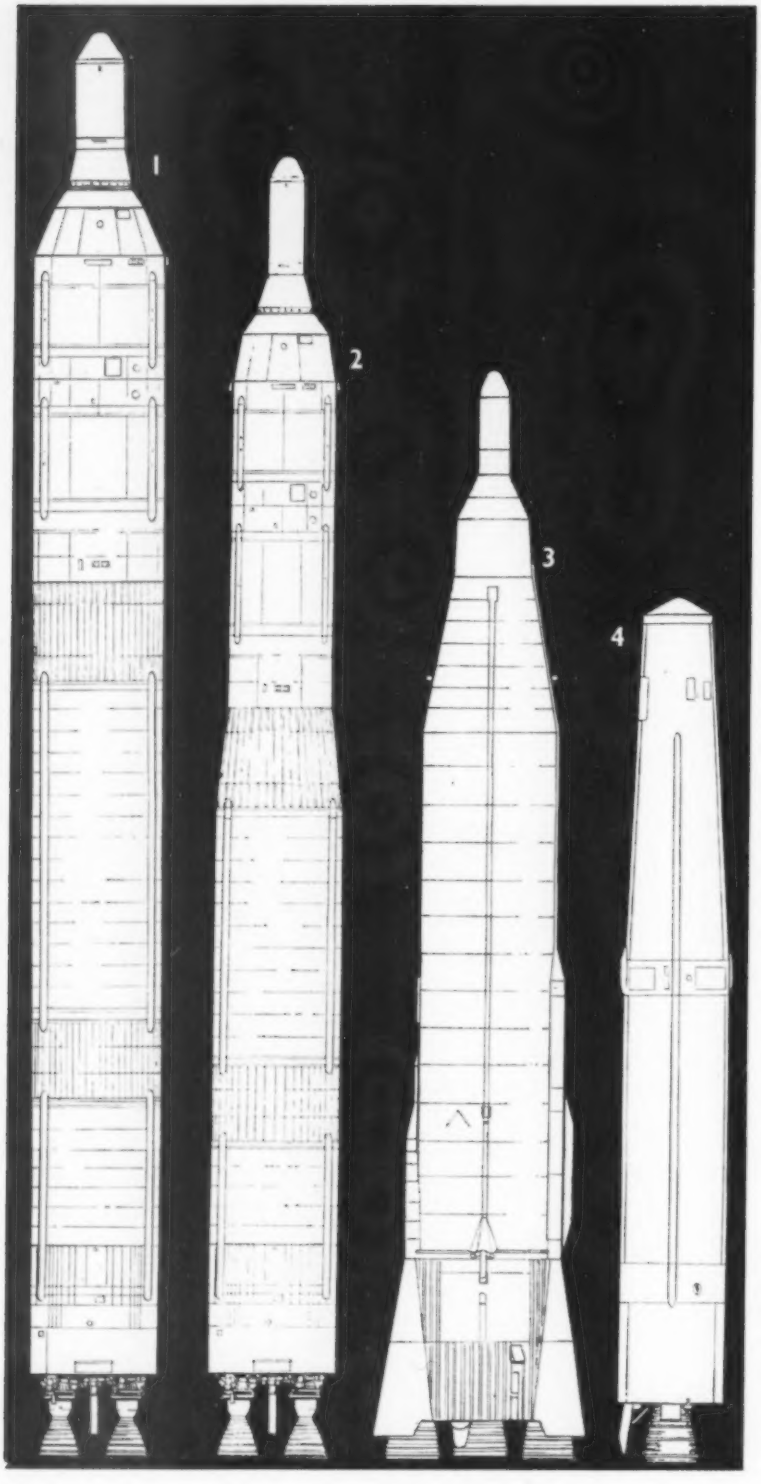

STRATEGIC BALLISTIC MISSILES: 1, Titan 2 (provisional); 2, Titan 1; 3, Atlas E; 4, Thor

SEREB (Société d'Etudes et de Réalisation d'Engins Ballistiques), which has now come to an agreement on space projects with Hawker Siddeley Aviation. No details of the IRBM have been divulged, although it is unofficially said to be solid-fuelled and—as one might expect—smaller than Jupiter or Thor. Presumably the nuclear tests in the kiloton range carried out in the Sahara have materially assisted in the development of the warhead, but the Colomb-Béchar range would have to be extended for full-range flight testing.

JUPITER

IRBM for deployment from mobile, soft emplacements

ITALIAN AIR FORCE AND TURKISH ARMY (*US Strategic Missile 78*)

DEVELOPMENT of this weapon system was initiated by the US Army Ballistic Missile Agency in 1956. The following year a famous memorandum by the then American Secretary of Defense forbade the Army any weapon with a range greater than 200 miles, and Jupiter was promptly transferred to the US Air Force. It became very much an orphan, and despite its excellent qualities of cheapness and mobility, found no employment in the US armed forces. Eventually plans were made —very much in camera, and never announced in any detail—for Jupiters to be established in Italy and Turkey. In both cases the units serve a purely NATO function, and may not be employed unilaterally by their own governments.

First of the formations to be activated was a squadron of the Italian Air Force. This was for many months receiving instruction from 864 SMS of USAF Strategic Air Command at Redstone Arsenal, and fired its first missile from Cape Canaveral on April 22 of this year. A total of 30 Jupiters is to be deployed in Italy, and unofficial reports have stated that bases for them (presumably for administrative and maintenance purposes, since the launcher can be located anywhere) have been constructed in south-east Italy in the neighbourhood of Puglia. The disposition of Turkish Jupiters has been kept even more completely under wraps, but by putting various unofficial reports together a hazy picture emerges. The original agreement to accept the missiles was made by the late Mr Menderes, and after his deposition there was pressure to have it rescinded. Various reports have named the Turkish Army as the user, and suggested that the number of missiles involved will be 15. Enquiries into the programme have met with evasive replies.

MINUTEMAN

ICBM for deployment from fixed, hardened bases

US AIR FORCE (*Strategic Missile 80*)

FIVE years of experience with the first-generation ICBMs has given the US Air Force a thorough knowledge of how such large and complex weapon systems can most effectively be designed, developed and put into operation. But after only two years (i.e., in 1957) it became painfully evident that these first-generation systems suffer from fundamental drawbacks, which seriously reduce their effectiveness and increase their cost. Apart from the last factor, these handicaps have been ameliorated, and improved versions of Atlas and Titan can be dispersed in hardened silos and fired with much reduced reaction time. Nevertheless, in 1957 the decision was taken to initiate an entirely new ICBM system capable of taking the fullest advantage of state-of-the-art improvements in several basic technological areas.

Even earlier, in 1955, a special office in the ARDC (now the Air Force Systems Command) had been set up to investigate the feasibility

TABLE 1: STRATEGIC MISSILES

	Propulsion		Length (ft)	Body diam (in)	Launch weight (lb)	Range (n.m.)	Burnout Mach number	Estimated warhead (megatons)
	Thrust (lb)	Propellants						
SM-65 Atlas D	2×150,000+60,000	LO_2+RP-1	82.5[1]	120	255,000	9,000	26	3[2]
SM-65A Atlas E	2×164,500+60,000	LO_2+RP-1	82.5	120	260,000	10,000	27	3
SM-78 Jupiter	150,000	LO_2+RP-1	60.3	105	110,000	1,500	12	1.5
SM-80 Minuteman	three stages	PBAA/PU	59.5	71	65,000	5,500	22	2
Polaris A-1	two stages	PU/AP	28	54	28,000	1,200	10	0.5
Polaris A-2	two stages	PU/AP	31	54	—	1,500	12	0.5
Polaris A-3	—	—	—	54	—	2,500	15	—
SM-75 Thor	150,000	LO_2+RP-1	65	96	105,000	1,500	12	1.5
SM-68 Titan 1	2×150,000+80,000[3]	LO_2+RP-1	98	120	220,000	8,000	26	4
SM-68B Titan 2	2×215,000+100,000[4]	N_2O_4+UDMH/H	102	120	300,000	12,000	28	5

Notes: 1, 75ft with Mk 2 re-entry vehicle; 2, can carry Titan heads; 3, in vacuo

of a solid-propellant ICBM. Some of the problems loomed very large, but the obvious advantages of such a missile, and the steady progress made by the Navy Polaris, resulted in the programme being placed on a firm basis at the end of 1957.

During 1958 the basic design was sketched as a three-stage vehicle standing no more than 60ft high, with a first-stage diameter of only about 6ft. It was envisaged that the first stage, or first and second, could be employed separately in order to meet requirements for "area-defence" or intermediate-range missions; but at an early stage it was realized that the correct course of action was to develop a 5,500 n.m. ICBM of the highest possible quality, and not to compromise its design by trying to make portions of the vehicle fulfil other tasks. It is particularly worth noting that the new techniques introduced into the design of this missile reversed the normal trend in that, for the first time, a better weapon was being produced at a substantially reduced cost.

An outline of the basic design of the system is contained in this extract from an article published in the journal *Ordnance*, by Capt Frank King of the former Ballistic Missile Division: "Minuteman is the optimum ICBM configuration considered after years of extensive research . . . It will be our first 'push-button' weapon system . . . The basic objective of the program is to initiate the complete development of a simple, low-cost weapon system capable of destroying enemy industrial areas with a high degree of reliability. The system is also designed to develop a capability as a counterforce weapon capable of attacking hard targets, such as other protected missile sites. . . . The Minuteman concept essentially encompasses a force of large numbers of missiles with fast-reaction, single-target capability per missile, hardened and dispersed operating facilities, utilization of existing DOD [Department of Defense] land, and a minimum of operational personnel. . . . Minuteman's smaller size, compared with liquid-propellant missiles, is primarily due to its three solid-fuel rocket engines, and lightweight warhead and guidance and control package. The third-stage motor also will permit thrust termination. Weight of the total missile will be in the 60,000 to 70,000lb class. . . . Minuteman will require approximately only 10 per cent as many men per missile as the larger ICBMs."

In October 1958 the Boeing Airplane Company (now the Boeing Company) were made the prime contractor for assembly and test. Although the focal-point of the large industrial team responsible for the weapon system, Boeing's Aero-Space Division at Seattle actually manufactures little of the missile itself. Development is managed by the Air Force Systems Command, and system engineering and technical direction are provided by Space Technology Laboratories Inc.

Essentially the missile consists of three solid-propellant motors of very advanced design, topped by a guidance bay and re-entry vehicle. After a great deal of development, the severe problems inherent in the manufacture of the cases and motor nozzles appear now to have been solved. Nevertheless, the breadth of the research programme into these components makes it virtually certain that no design will ever be regarded as final. For example, although high-tensile metals are at present used for the manufacture of the first- and second-stage motor cases, it is hoped that weight can be reduced still further in the future by the substitution of reinforced plastics.

Contractor for the first-stage engine is the Thiokol Division of Reaction Motors, whose Wasatch division have built a special plant in Utah for this purpose. Several companies, especially Allison division of General Motors, have made the cases for this stage, but all production models appear to be fabricated by precision-welding stainless-steel sheet with a u.t.s. of some 300,000lb/sq in. The lower end closure bulkhead is a convex pressing perforated by four large holes into which are screwed the four propulsive nozzles.

Development of nozzle systems capable of providing thrust-deflection for trajectory control was initially the chief mechanical problem facing the Minuteman designers. The only previous example of a large solid engine of such advanced design was the first stage of Polaris. In the latter missile four nozzles were preferred to one large nozzle in order to reduce missile length, while jet-evators (curved-section rings surrounding the nozzle exit) were considered to be the only feasible method of achieving such thrust deflection in the uncooled nozzles of a solid engine.

MORE STRATEGIC MISSILES: 5, Minuteman; 6, Jupiter; 7, 800-mile Russian missile first seen this year; 8, 500-mile Russian missile seen since 1957; 9, Polaris A-2; 10, Polaris A-1

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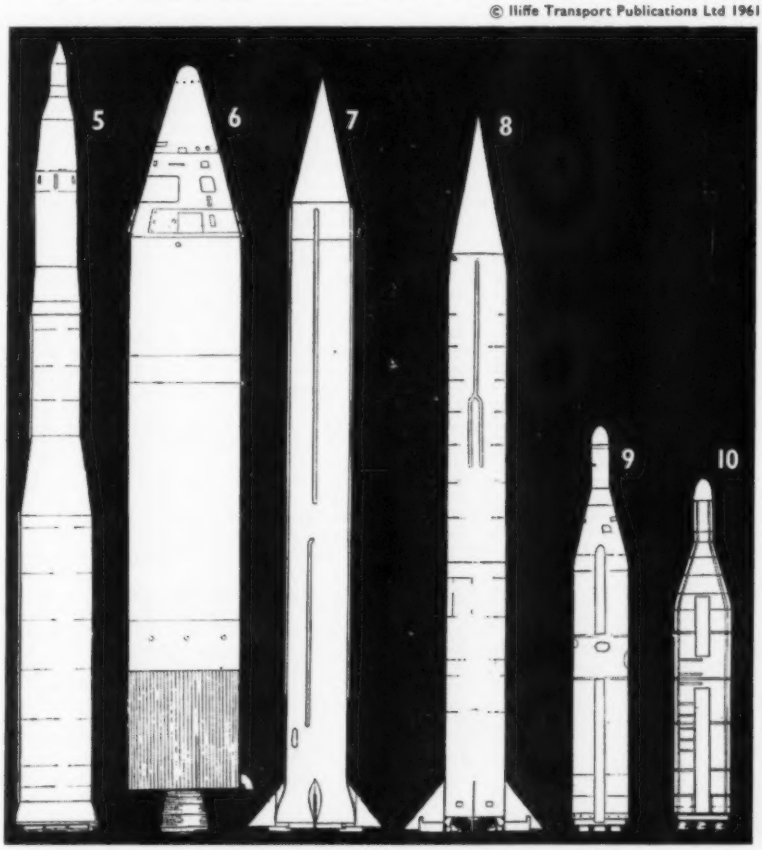


The first stage of Minuteman is very much larger than that of Polaris, and the combustion pressure and temperature are even higher than the challenging figures chosen for the naval missile. Yet a method was finally found of making a gimballed nozzle, which increases vehicle performance and may be lighter than the best jetevator system. All four nozzles are pivoted about a radial axis, and are driven hydraulically to control the missile in pitch, yaw and roll up to the point of first-stage burnout. Each nozzle is spherically seated near its base, and means have been found of minimizing erosion at the throat (which would cause the expansion area-ratio to alter).

The propellant is a mix of polybutadiene acrylic acid plus an ammonium perchlorate oxidant, with a Thiokol binder and a small proportion of an aluminium-based additive to ensure smooth combustion. After inspection, the case is coated with a liner, similar in composition to the propellant, which is bonded on and cured to ensure that when the case is filled there will be no tendency of the propellant to break away.

Second-stage propulsion is the responsibility of Aerojet-General, who were originally backed up by a different pattern of engine by Thiokol. Aerojet-General are also prime contractor for propulsion in the Polaris programme, and they have stated that the technological design of the Minuteman propulsion is of an even more advanced nature. In spite of their long experience with jetevators, four gimballed nozzles were chosen for the second stage also, and it is unofficially reported that the propellant is a Polaris-like mixture of a polyurethane and finely divided aluminium. Second-stage cases have in the past been fabricated entirely in stainless steel, but Lycoming and Allison have conducted extensive research into titanium cases, and the latter has now received a contract from Aerojet-General for development and production of second-stage cases in titanium. Described as being "machine forged," the new cases weigh roughly 70 per cent as much as the steel cases, and are claimed to make possible longer-range versions of Minuteman. Their delivery has already begun.

After keen competition, the contract for the third-stage engine was won by Hercules Powder Co. Their case is a unique Spiralloy glass-plastic structure, between the inner and outer multi-layer coatings of which is wound 188,604 miles of continuous glass filaments. Again there are four thrust chambers, each spherically seated and pivoted about a radial axis. This third stage incorporates explosively actuated venting ports to ensure precise thrust termination.

Very few details have been divulged concerning the guidance system and re-entry vehicle. The former, by NAA Autonetics, is a pure-inertial system, with an entirely new design of stable platform, complete transistorization and a sub-miniature digital computer which is said to monitor several of the internal missile systems before liftoff. Weight of the airborne guidance is unofficially put at 180lb. Each of the three stages of the missile contains its own source of electrical power, consumed and jettisoned in sequence with the rocket engines; references have been made both to Ag/Zn batteries and to a solid-fuel a.p.u.

Standard re-entry vehicle is the Mk 5 ablative pattern developed by Avco. It has been suggested that the warhead yield is less than that of the first-generation missiles (see table of data), and there seems little doubt that the fully loaded Mk 5 vehicle weighs only about one-third as much as do the corresponding designs for Titan and Atlas. The ablative material is Avcote, which—it is said—may later be replaced by cork.

When we wrote our 1960 review it was anticipated that, of the approximately 600 Minuteman missiles to be deployed by the end of 1964, 450 would be put into holes in the ground and the remaining 150 would be carried by special trains from which they could be launched almost anywhere within the United States. Earlier this year the concept of mobile deployment suddenly appeared less attractive, for reasons which have not been divulged and are far from being self-evident. In the fiscal year 1962, which started on July 1, no money is allocated to the mobile Minuteman, and the whole idea may even have been abandoned. The mobile missile was to be transferred from road transporters to the railway launch car at special centres each incorporating two four-storey buildings. Each launch car would have housed a single missile located inside close-fitting "strongback covers" stressed to hold the weapon horizontally. For launching, the major portion of the roof would open into left and right halves, and after elevation to the vertical position the strongback covers would be opened like petals to allow the missile to depart.

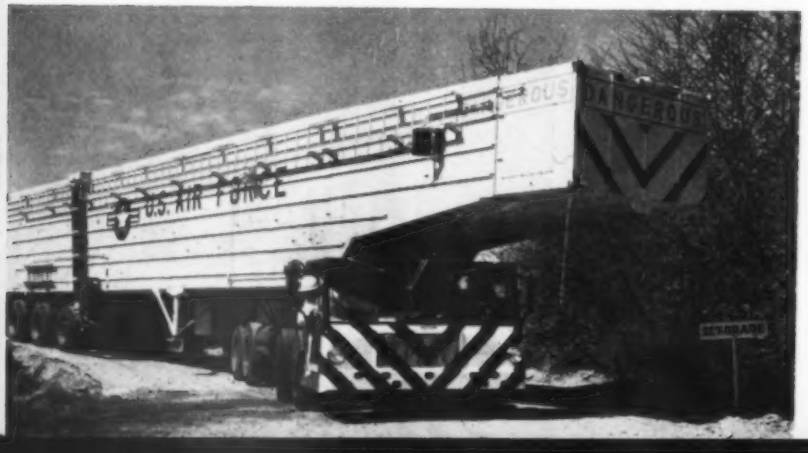
Compared with the first-generation ICBMs Minuteman requires practically no cyclic inspection and maintenance. Accordingly the fixed-base missiles will be hardened and dispersed in unmanned remote silos, connected in groups to a single hardened launch control centre. A map of the first Minuteman launch complex (page 710 of our 1960 review), reveals the disposition of the first three squadrons near Malmstrom AFB, Great Falls, Montana. Each squadron will normally consist of five flights, each comprising a launch control centre and ten silos. Thus, a squadron will have 50 missiles (the first has 55) and a complete complex no fewer than 150. If Malmstrom is typical, the silos are located from five to ten miles apart, and the complete Malmstrom complex measures 190 miles by 90 miles.

Basic dimensions for the silo are: depth, 80ft; width, 12ft; interior floor levels, first equipment room, 20ft below surface, second equipment room 28ft below surface. Unlike the enormous installations required by Titan or Atlas, each silo is virtually no more than a single blast-resistant concrete tube. All equipment is shock mounted; systems used during an alert period are housed in a building above ground level, but everything necessary for an actual launch is hardened in the two underground equipment rooms. Communications are vital in ICBM operations, and particularly so when the missiles are not manned. Details have been given of the unusual earth-current radio network developed by Boeing and Sylvania, which employs buried aerials and is both foolproof and unjammable. This system is employed not only for initiating a launch but also for checking-out missiles periodically.

Boeing have listed the following major milestones in the Minuteman programme thus far: October 10, 1958, Air Force announces selection of Boeing as assembly and test contractor; September 15, 1959, full-size Minuteman model successfully test-fired from underground silo launcher at Edwards AFB during tethered tests, exactly on schedule set when Boeing joined programme; November 30, 1959, Hill AFB, Utah, selected as site for first Minuteman assembly and recycle facility; March 3, 1960, first flight-weight missile, equipped with prototype control and guidance system, used in sixth tethered silo firing; March 23, 1960, selection of Malmstrom AFB, Montana, area as site of first Minuteman hardened and dispersed launch complex; May 6, 1960, Press witnesses final (eighth) tethered firing at Edwards; June 20, 1960, first mobile test train left Hill AFB to test communications systems, personnel requirements and ability of railroads to handle missile trains moving at random on rail network; July 19-22, 1960, Development Engineering Inspection held at Boeing, Seattle, for hardened and dispersed portion of programme (first US ICBM which required no major modifications of equipment or engineering concepts before flight-test programme); August 26, 1960, fourth train deployment from Hill AFB completed, and Air Force announces it will be capable of moving and launching Minuteman missiles from any point along US rail network; September 15, 1960, ground broken at Hill AFB for Minuteman assembly facility to be operated by Boeing; December 7-9, 1960, Development Engineering Inspection held at Boeing in Seattle for mobile Minuteman; January 4, 1961, Ellsworth AFB, South Dakota, announced by USAF as second hardened and dispersed Minuteman base; February 1, 1961, first launching of Minuteman at Cape Canaveral results in most successful first flight ever accomplished in US missile history; May 19, 1961, second launching at Cape Canaveral is partial success, missile being destroyed by range safety officer; July 27, 1961, third launching at Cape Canaveral a complete success.

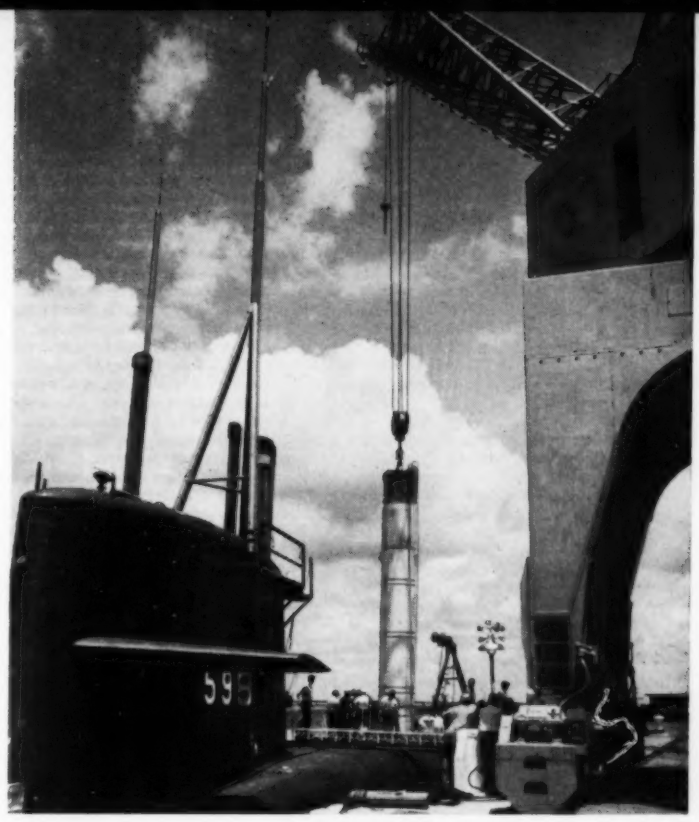
There is no doubt that the success of the first flight last February 1 was remarkable. It was the first time a multi-stage missile had ever been fired on its maiden flight with propulsion in all stages; it was also the first time a missile had used its own internal guidance system on its first flight. The range achieved was about 4,600 miles, and the successful launch of July 27 led to a 5,000-mile mission. But Boeing have not had everything their own way, and Minuteman No. 4 blew up on August 30 in what was described as "the biggest explosion ever seen at Cape Canaveral." This was the first full-scale firing from an underground silo, and although the missile cleared the rim of the silo successfully the flight was terminated either by faulty triggering of second-stage propulsion or by a catastrophic malfunction of the control system. After inspecting the wreckage, the USAF announced that operational capability of the missile would not be delayed.

The tractor-trailer combination for Minuteman is the largest vehicle ever designed for regular highway operation. Built by General Motors, Cessna and Bendix-Pacific, it transports the missile in a controlled atmosphere and then lowers it into its silo



Initial operational capability for the first squadron at Malmstrom is scheduled for the summer of next year (probably June 30). Base construction at Malmstrom began in January of this year, and the Corps of Engineers are due to finish the work progressively between next March and June. Construction costs per launch complex are put at $60m, less than one-tenth that of building bases for 150 hardened Atlases or Titans. The US Air Force have not named any Minuteman squadron, but have announced that the next three launch complexes will be dispersed around Ellsworth AFB, Rapid City, South Dakota; Minot AFB, North Dakota; and Whiteman AFB, Missouri.

Assembly of production missiles is soon to begin at Hill AFB, in the new factory established by the Boeing Company at Ogden, Utah. The completed missiles, and much of their associated support equipment manufactured in Seattle, will then move to the Malmstrom launch complex, where the complete weapon system is assembled one silo at a time "like pouring batter into a series of cupcake tins" (Boeing's words). When the Malmstrom complex is finished, final assembly will move to the second complex. The maximum number of persons employed in final assembly at the silos will be roughly 1,500, which is somewhat less than half the number engaged in base construction.



USS "George Washington," first of the Fleet Ballistic Missile submarines, reloads her 16 launch tubes preparatory to conducting submerged launchings. In the photograph, the glass-fibre inner liner is positioned above the launch-tube hatch to locate the missile

POLARIS

Ballistic missile for launching from submerged submarines

US NAVY

IN our 1960 review we began the account of this missile with the words "The successful firing of two Polaris missiles from the first Fleet Ballistic Missile submarine on July 20 must be regarded as perhaps the most significant single accomplishment in the whole history of guided weapons since 1943." As described in a two-part article published by this journal on July 22 and 29 last year, the development of the concept of a submarine-launched missile, and its translation into usable hardware, is a truly remarkable engineering achievement, particularly when the compressed time schedule is also taken into account.

A brief account of the genesis of Polaris appeared in *Flight* for March 30 last, when a series of drawings traced the development of the missile from the original concept of a Jupiter IRBM modified for use by surface ships. The US Navy justifiably showed little enthusiasm for a large liquid-propellant missile, and collaborated with Aerojet-General and the Missile and Space Department of Lockheed Aircraft (now Lockheed Missiles and Space Co) in the progressive evolution of a solid-propellant weapon. The first sketch came out only fractionally smaller than the original Jupiter, and had a central motor surrounded by six others. But towards the end of 1956 dramatic advances—"breakthroughs" in American parlance—in solid-propellant technology, thermonuclear warheads, inertial guidance and lightweight re-entry vehicles, all combined to open the way to the development of a missile very much smaller and lighter than anything previously considered feasible.

For the design range of 1,200 n.m. the launch weight was slashed from 160,000lb to approximately 30,000lb, and the Polaris project was put on a firm basis in January 1957. The dimensions of the missile were of such an order that the dream of submarine launching appeared feasible, and very quickly this was accepted by the Navy as the basis for a complete delivery system. This weapon system is perhaps the largest and most costly in the world; and the Air Force and other critics have frequently pointed out that the Polaris warhead is really delivered by a three-stage vehicle with a first stage weighing 6,000-odd tons and costing $100m. In return, the Navy point out that the first stage is re-usable, and can launch its missiles from the darkest recesses of the ocean. The vulnerability of the fast, nuclear-powered Fleet Ballistic Missile submarines has been most carefully evaluated, and is officially described as "not very great" (said with calm assurance). It is certainly true that, unless the vessel is shadowed continuously from the moment it leaves port, it is extremely elusive and far more difficult to find when lurking on-station than is a much smaller submarine in motion.

During 1957, when the feasibility of many portions of the weapon system had yet to be proved, the Navy decided to slice through one of the largest nuclear submarines then under construction by the Electric Boat Co and insert a large section aft of the central "sail" to house the missiles. The method of carrying and launching the Polaris is of singular interest. At an early stage it was deemed unsafe to fire the missile's propulsion system anywhere in the vicinity of the parent vessel. After investigating a variety of floating arrangements, it was concluded that the optimum answer was to employ a system essentially similar to that used for many years for launching torpedoes.

Each submarine carries 16 missiles in vertical launch tubes arranged in two rows of eight. These tubes are loaded from the shore establishment at Charleston, South Carolina, or from the depot ship USS *Proteus*, stationed in Holy Loch, Scotland. The missiles are protected by a cylindrical liner which is lowered by a crane through the double deck-hatches of the tube concerned. When the submarine is at sea, the missiles in their tubes can be continuously monitored and checked out, and are at all times linked with the ship's navigation system. To fire a missile pneumatic pressure from a high-capacity accumulator system is applied to the base of the tube, discharging the missile vertically upwards at an initial velocity probably greater than 100kt.

Simple as this sounds, in practice many severe problems had to be overcome. No details may be given of the depth at which a missile may be fired, but it is generally thought to be of the order of 75 to 95ft. Hydrostatic pressure at such depths is very great in comparison with the pressures normally experienced by flying vehicles, and the submarine has to feed a pressurizing gas into the missile to equalize the pressures across the skin of its airframe. This must be done so that the pressure builds up at the same rate as does the external pressure of sea water in the launch tube after the hatches are opened. Then, as the missile shoots to the surface, the internal pressure must be bled away in a controlled manner, so that at the moment the missile appears above the waves the internal pressure is close to atmospheric.

Another major difficulty was caused by cavitation. Hydrodynamicists are familiar with the damage caused to propellers by this phenomenon, which is basically a breaking-away of the water from the surface owing to excessive local flow velocity and/or turbulence. The very high speed of the missile through the water meant that its shape had to be carefully chosen, for cavitation would have caused structural failure. Other problems were caused by the necessity of launching in any kind of sea state. Lockheed investigated the properties of waves, and their effect upon the missile's exit from the sea. Moreover, Polaris is hydrodynamically unstable, so that its initial speed must be sufficiently high for it to depart only slightly from the vertical during its journey through the water.

Something should now be said of the missile itself. The first operational version is the Polaris A-1, with a design range of 1,200 n.m. (1,380 miles). Its cylindrical body has a diameter of 4ft 6in, and consists entirely of two

solid-propellant motors arranged in tandem. Aerojet-General have chosen a cast polyurethane/perchlorate composite solid propellant, with an aluminium additive to prevent unstable combustion and increase specific impulse. To reduce the overall length of the vehicle each stage has four small nozzles, all provided with ring-like jetevators to control the trajectory in pitch, yaw and roll.

Motor cases in the A-1 missile are fabricated by precision-welding high-strength stainless-steel sheet. The second stage incorporates thrust-termination ports, and unusually complex ignition, destruct and safety systems are necessary for submarine use. Ignition takes place as soon as the missile breaks the surface of the sea. Actual underwater launchings have demonstrated the ability of the control system and jetevators to correct for exits as much as 40° from the vertical. During first-stage propulsion the missile is gradually tilted over towards the target, and the first stage burns out and separates at a height of about 12 miles. The second stage then ignites, and is cut off when the missile arrives on the correct trajectory at the exact speed for the range demanded. The warhead than separates.

Yield of the original warhead is said to be 0.5MT, a modest figure which, coupled with revolutionary design, was instrumental in enabling the re-entry vehicle to be made very much smaller than any others. Although the nosecone is essentially of the heat-sink type, the re-entry configuration set a new standard which has since been followed by all the larger ablative models for the ICBMs. During the launch the nose is protected by a rigid plastic envelope, which burns up during re-entry.

Notwithstanding the great difficulty of guiding a submarine-launched missile to a distant target, the circular error probability (accuracy) of Polaris is stated to be "of a high degree"; unofficial statements suggest that it may be of the order of half a mile. To achieve such accuracy, the submarine must know its own position at the moment of firing and also the exact relative position of the target. The heart of the submarine's navigation system is SINS (ship's inertial navigation system), chief contractors for which are jointly NAA Autonetics and Sperry. Several systems are integrated to provide cross-checks on each other, and gyroscopes and accelerometers not only continuously record position but also monitor the ship motion and attitude, for, even at a depth of 80ft, the vessel may pitch or roll slightly. General Electric, at Pittsfield, supply the fire-control system, which feeds a continuous flow of co-ordinated information into the missile up to the moment of firing. The signals include position of the launch tube, true north, target location and trajectory to be flown. It can prepare missiles for launching at the rate of approximately one per minute. Major contractors for checkout equipment are Nortronics and Lockheed Electronics, while Interstate Electronics are a major supplier of instrumentation. Westinghouse Electric is the contractor for launching and handling systems, and the all-inertial airborne portion of the guidance system is being produced by two teams, led by GE and Hughes, the original system having been designed by MIT.

Testing of the A-1X series of vehicles started in September 1958, and the first with a live second stage accomplished all test objectives on May 8, 1959. Three months later a missile was launched successfully from a ship-motion simulator at Cape Canaveral, and only two weeks afterwards another was successfully launched from a tube mounted on the surface ship USS *Observation Island*. Meanwhile, tests aimed at developing the ejection and underwater-launch capability were carried out off San Clemente Island and at other California locations.

The Navy has suggested 45 as being the optimum number of submarines for the most efficient implementation of the Fleet Ballistic Missile System on a world-wide basis. To date, 29 submarines have been requested, the last ten being on an accelerated basis to enable all 29 to be operational by early 1965. The first five have a displacement of 5,400 short tons surfaced and 6,700 submerged, and are 380ft long. These submarines are USS *George Washington*, *Patrick Henry*, *Robert E. Lee*, *Theodore Roosevelt* and *Abraham Lincoln*, and all are in commission. The first-named conducted the two pioneer underwater launches on July 20 last year, and the first four ships are on what the Navy is pleased to call "peace patrol." The next class of ships, which are steadily being completed, are of 6,900/8,600 tons displacement, and are 410ft long.

All the ships at present in commission are equipped to fire the A-1 missile. Polaris A-2, with a design range of 1,500 n.m., differs externally from the earlier missile only in being 3ft longer. When the first five ships are overhauled (probably three years from commissioning) minor modification will permit them to be re-armed with the longer-range missiles, bringing them up to the standard of the remaining 24 ships.

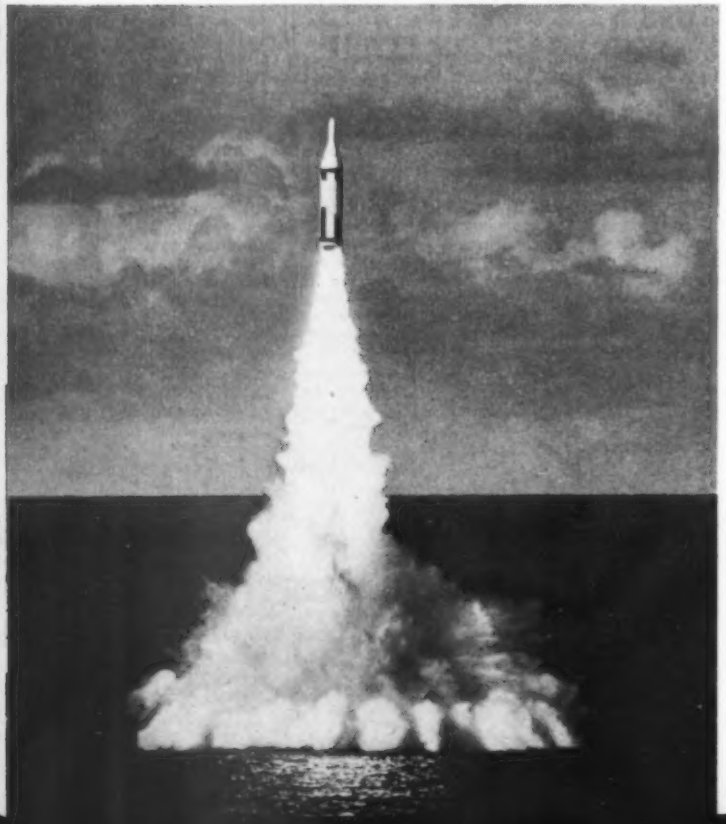
Polaris A-2 has an entirely new second-stage motor case made of reinforced plastics. The Spiralloy process patented by Hercules Powder Co combines 267,930 miles of glass filaments and epoxy resin to produce a low-density shell of extreme strength. Similar designs of second-stage cases are made by Aerojet-General and B. F. Goodrich. The complete motor, assembled at Allegany Ballistics Laboratory, contains a new propellant of increased specific impulse, which is responsible for most of the extension in range.

Flight trials of Polaris A-2 began on November 10, 1960. The programme has been intensive, no fewer than 10 A-2s having been launched by May 9, and the current total being approximately 17. Several of the most recent firings have been from the trials ship *Observation Island*. Underwater launches have begun with firings from *Ethan Allen*, the first of the larger FBM submarines, which launched her first A-1 missile on October 16, followed by an A-2 on October 23.

At the time of writing, the ultimate firm Polaris development is the A-3, with a design range of 2,500 n.m. President Kennedy has requested that development of this weapon be accelerated, so that it may be available in 1964. Few details of its design have been divulged, apart from what was contained on page 414 of *Flight* for September 14 of this year.

It was then reported that severe troubles had been encountered by Aerojet-General in attempting combustion conditions with the double-base fuel in the first stage of 6,300/6,600°F and 800/900lb/sq in. These conditions are indeed ambitious, yet any reduction would be reflected in corresponding curtailment of range. The cases, however, appear to be relatively trouble-free, both being of filament-wound glass stressed to 80,000lb/sq in and weighing only 800lb (first stage) and 200lb (second). Proof pressure for these cases is 945 and 342lb/sq in respectively.

Launch of the Polaris A-1 from submerged submarines is now a routine operation. In this photograph a missile is seen shortly after first-stage ignition, after pneumatic expulsion at a depth of 80ft



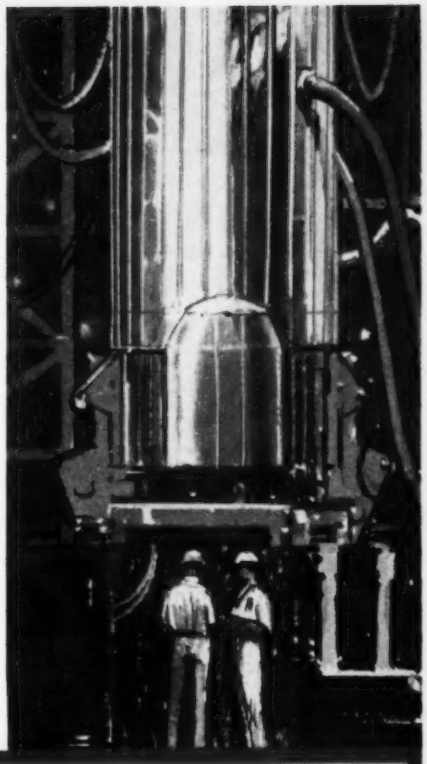
SNARK

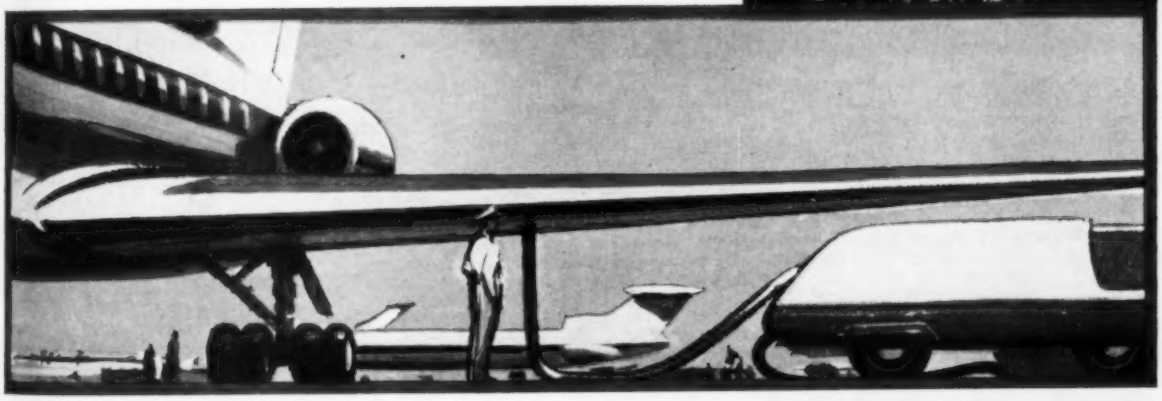
THIS aerodynamic-cruise strategic weapon is no longer in service with the US Air Force. Details were given in our four previous reviews.

SOVIET MISSILES

PIECING together a picture of Soviet strategic weapons is always a bricks-without-straw operation. Practically all details of such weapons are closely shrouded by security, and part of what follows is necessarily deduction or even supposition. It is generally considered that all the Russian space launchings have been boosted by vehicles of a basically military nature, although the payload/velocity per-

Down go fuelling costs with the new A.W.E. fuel coupling





A new comprehensive range of aircraft mounted coupling units for aviation fuelling is now available ex stocks at A.W.E.

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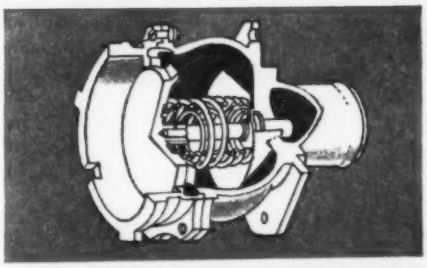

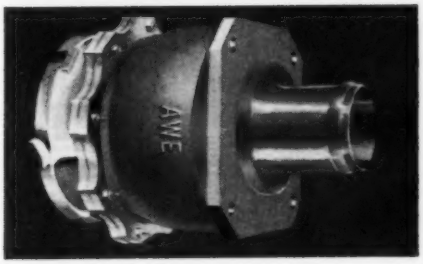

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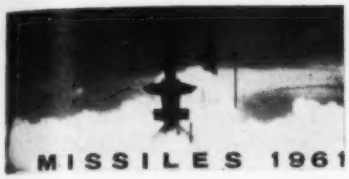
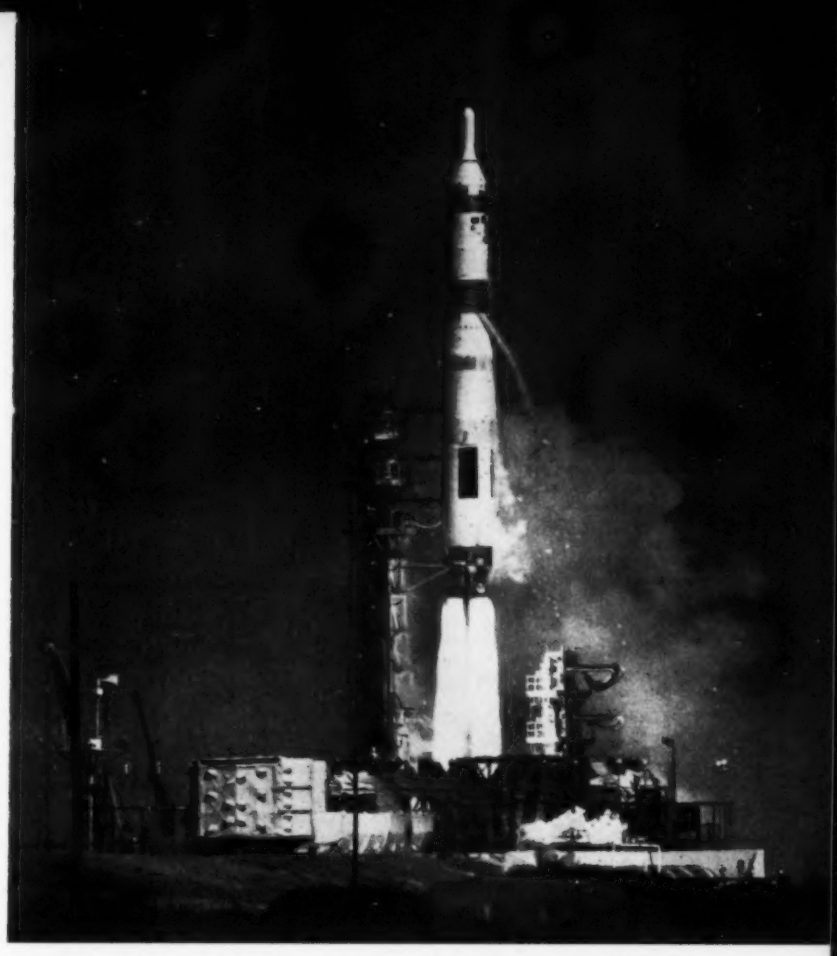


formance of the latest Sputnik and Vostok vehicles would appear to be much greater than would be necessary to deliver even the fearsome 100MT warhead of which Mr Krushchev has spoken. Considered conclusions regarding the vehicles used in Russia's space programmes were contained on pages 230-1 of *Flight* for August 17 of this year.

Numerous "multi-stage carrier rockets" have been launched over ranges in the bracket 7,450 to 8,078 miles from an unstated place or places to a designated target area in the central Pacific. These firings took place in January and July last year, and throughout last month. Each series of tests was said to involve a "new" or "more advanced" type of vehicle, and in every case extreme accuracy was claimed. On at least six of the last nine firings it was announced that the dummy final stage, adapted for passage through the atmosphere, struck the water close to the calculated impact point.

Regarding submarine-launched weapons, Mr Krushchev announced a year ago that his country had "submarines with atomic engines, armed with rockets," and the *Tass* news agency made a similar claim two weeks ago. In contrast, the US Chief of Naval Operations said last month that, while Soviet submarines had been observed to have "certain capabilities for launching missiles," they did not appear to be capable of launching missiles while submerged.



Titan, by Martin's Denver Division, has a greater payload/range performance than any other missile outside the Soviet Union. In this photograph a J-series missile is seen departing from Cape Canaveral on a test flight down the Atlantic Missile Range

THOR

IRBM for deployment from fixed, soft emplacements

ROYAL AIR FORCE (*US Air Force Weapon System 315A, Strategic Missile 75*)

AT a time when no modern ballistic missile had been fired outside Russia, the complete Thor weapon system was produced as a crash programme in the incredibly short period of ten months, from receipt of the development contract by Douglas Aircraft in December 1955 to delivery of the first SM-75 missile to the USAF in October 1956. For obvious geographical reasons this fixed-base weapon is not in the inventory of Strategic Air Command, but it is the only strategic missile in the United Kingdom or in British hands anywhere. A total of 60 Thors are emplaced by 20 squadrons of Bomber Command occupying four complexes extending from Yorkshire to East Anglia, as described in *Flight* for February 19 and March 11, 1960. Full details of the weapon system were given in the issues dated December 5, 1958, and May 22, 1959. At the time of writing, 129 firings have resulted in 100 successes and 13 partial successes, and scientific launchings boosted by Thor have put 39 payloads in space.

TITAN

ICBM for deployment from fixed, hardened installations

US AIR FORCE (*Weapon System 107A-2, Strategic Missile 68*)

DURING the development of the Atlas it appeared increasingly that, while the concept of an ICBM was so attractive as to demand a crash programme and the maximum possible rate of expenditure, the technological problems attending such a deep penetration into uncharted regions were so severe that the possibility of obtaining a usable weapon was by no means certain. In 1953 the Strategic Missiles Evaluation Committee recommended that contracts should be placed for a second type of ICBM, differing where possible from Atlas, while reaping the maximum reward from the experience already gained with the earlier missile. This back-up insurance programme was named Titan, and given the number WS-107A-2, for the design requirements were initially identical with those specified for Atlas.

Prime contractor is the Martin Company, chosen in October 1955. To handle the programme, Martin and the Air Force jointly built and equipped a vast new factory near Denver, Colorado, which builds and equips the complete missile and then conducts static testing before despatch to the customer.

Chief innovations introduced by Martin were the following: two-stage propulsion, with the second stage ignited above the atmosphere; hardened deployment (this may not have been demanded in the original specification, but the emplacement evolved as a silo); and vertical storage, with the missile fully assembled. Although in no way an innovation, the new missile differed from its predecessor in having propellant tanks made sufficiently rigid for the airframe to be stable, when either horizontal or vertical, without internal pressurization.

Both stages of the missile are built up from relatively thick sheets of aluminium alloy, which are chemically etched and machined before being curved to the body profile and joined in horizontal rotary jigs to form complete tank sections. The first stage has a diameter of 10ft, and the liquid-oxygen tank is placed above that for the RP-1 fuel. The second stage, which weighs about 48,000lb loaded, has a diameter of 8ft, and the relative positions of the tanks are reversed.

Propulsion is the responsibility of Aerojet-General. For the first stage they have developed an engine with a pair of gimballed chambers side-by-side, their thrust being transmitted to four points around the base of the airframe through a triangulated structure of welded steel tubes. Stage separation occurs at about 130 sec. The second-stage engine has a single gimballed chamber, with an expansion ratio (25 : 1) matched to vacuum conditions. The second-stage turbopump gas-generator discharges its exhaust through four small nozzles spaced at 90° around the base of the stage in order to provide vernier thrust for accurate final trimming of velocity. The thrust from these nozzles also facilitates a clean separation of the two stages.

Originally Titan was to have introduced pure-inertial guidance into ICBM operations, in contrast to the radio/inertial system developed for Atlas. However, in 1958 the decision was taken to switch these two guidance systems. As a result, the Atlas has the unjammable pure-inertial system, with salvo capability, while the first Titan squadrons are tied to the possibly more accurate radio command guidance. Western Electric is chief contractor. Powerful ground radars (by Sperry, although GE was the contractor for the Atlas radar) track the flight of the missile up to second-stage burnout, providing data for a Remington Rand (Univac) digital computer which produces steering signals transmitted to the

Photographed by "Flight" in cutaway model form in New York last month, Titan 2 has not previously been illustrated

missile by a Bell Telephone Laboratories radio system. Later Titan squadrons will have missiles equipped with an entirely new AChiever inertial system by AC Spark Plug in Milwaukee, which promises to be of outstanding merit. Its computer is said to memorize trajectories to many targets, the one selected being told to the missile before liftoff.

Owing to its excellent payload/range performance, the warheads designed for Titan are very large for a missile, and unofficial sources suggest the figures given in Table 1. To house these fearsome warheads Avco initially investigated a heat-sink re-entry vehicle but very shortly switched to one of the first US ablative designs. The present Avco Mk 4 is manufactured by Lycoming in Stratford, Connecticut, to designs by the Avco Research and Advanced Development Division in Wilmington, Massachusetts. It is basically cylindrical, has a diameter greater than that of the corresponding portion of the GE Mk 3 vehicle and the flared skirt at the rear is relatively short. This very impressive re-entry vehicle is now frequently seen on Atlas, while the lighter Mk 3 has flown great distances boosted by Titans.

After a series of delays, Titan 1 flew for the first time from Cape Canaveral on February 6, 1959. Like the two subsequent flights, this mission was limited to about 350 miles, the second stage being a dummy ballasted with water. The fourth launch (Titan A-6) took place on May 4, 1959, and, although propulsion was not fitted to the second stage, solid-propellant rockets were attached to its base in an endeavour to achieve separation. Then followed a long run of failures, broken by separation with a live second stage on February 2, 1960, by Titan B-7A (last of the B-Series), when the radio/inertial guidance system was coupled up to control the trajectory on a flight limited by the quantity of propellants to approximately 2,200 miles.

Throughout last year Martin were delivering Series C and Series J Titan 1 missiles for flight-testing at Cape Canaveral, while a small series of Titan Vs was flown across to the 395th SMS at Vandenberg AFB for troop-indoctrination training and silo compatibility tests. Numerous full-range flights were made, and at the time of writing the score is 31 complete successes in 41 firings. Among the more outstanding missions this year are the following: February 10, full-range flight by Titan J-11 with trajectory followed extremely accurately by cameras photographing 2m candlepower strobe lights; June 23, unsuccessful first launch with AChiever inertial guidance; July 21, full-range flight by M-Series missile with solid-rocket decoys, six of these being fired at separation of the re-entry vehicle and the remaining four fired on re-entry; July 25, successful flight with inertial guidance; and most important of all, the launch of May 3, in which the firing took place from the bottom of a silo. This is referred to again presently.

Titan 1, or SM-68A, is to equip six squadrons of Strategic Air Command, each of which will man three triple complexes. In other words, the operational strength of this missile will reach 54, plus one spare per squadron. The complex (*Flight*, November 4, 1960, page 709) is entirely underground, constructed by a cut-and-cover method, with silos and other structures all of heavy reinforced concrete. Statistics given for a typical complex include: 700,000 cu yd earth; 96,000 cu yd concrete; 24,000 short tons steel; 60,000 US gal stored water; and 4,000kW electricity.

At one end of the complex are the three silos, each sealed by a pair of 200-ton doors and incorporating liquid-oxygen and RP-1 propellant tanks, and transfer nitrogen. Tunnels lead to the launch control centre, powerhouse, water storage, air-filtration, main portal, and, at the far end half a mile from the missiles, radio guidance and aerial silos. Everything is designed to withstand an atmospheric overpressure of some 300lb/sq in, equivalent to a near miss with a 10MT warhead. Special measures are necessary to arrest radiation and prevent fallout from entering the air system, which may have to keep the launch crew of 200 alive indefinitely.

The original idea was that Titan should be hoisted hydraulically to the surface before firing, and this is essential for Titan 1. Nevertheless, the missile is designed for exceptionally rapid propellant loading, and total reaction time is believed to be less than ten minutes. Should the warning time be less, the complex is designed to be able to accept the nuclear onslaught and then poke up its three missiles and fire them.

Of the six Titan 1 squadrons, only the two (18 missiles) based at Lowry AFB are nearing operational service. Lowry has to some extent benefited by its relative proximity to Martin's missile plant at Denver, but labour disputes, serious accidents, a succession of unforeseen difficulties, and possible underestimation of the sheer magnitude of the Herculean task, have combined to delay the schedule and increase the cost beyond the expected figure of $80m for both squadrons. The first Lowry squadron is now expected to become operational next month, some six months late. The remaining four squadrons are all dispersed: one each at Ellsworth AFB, Rapid City, South Dakota; Larson AFB, Moses Lake, Washington; Beale AFB, Marysville, California; and Mountain Home AFB, Idaho.

TITAN 2

While Boeing develop the Minuteman second-generation ICBM, Martin have continued to "stretch" and otherwise improve the larger Titan in order to produce a vehicle with a much greater payload/range potential but similarly enjoying the ability to be fired with a reaction time of only a few seconds. The elimination of a countdown not only implies perfect reliability but also necessitates long-term storage of the missile with all its tanks filled. In turn, this eliminates traditional cryogenic (low-temperature) propellants, notwithstanding considerable research into continuous insulation and topping-up systems.

By mid-1958 Martin had planned Titan 2, or SM-68B, as a missile which would not only possess the essential and elusive instant-readiness capability, but also would be dimensionally larger and burn a propellant combination of comparable specific impulse. As a result, its payload/range figure is double that of Titan 1, which was itself greater than that of any other ballistic vehicle of its generation (outside Russia).

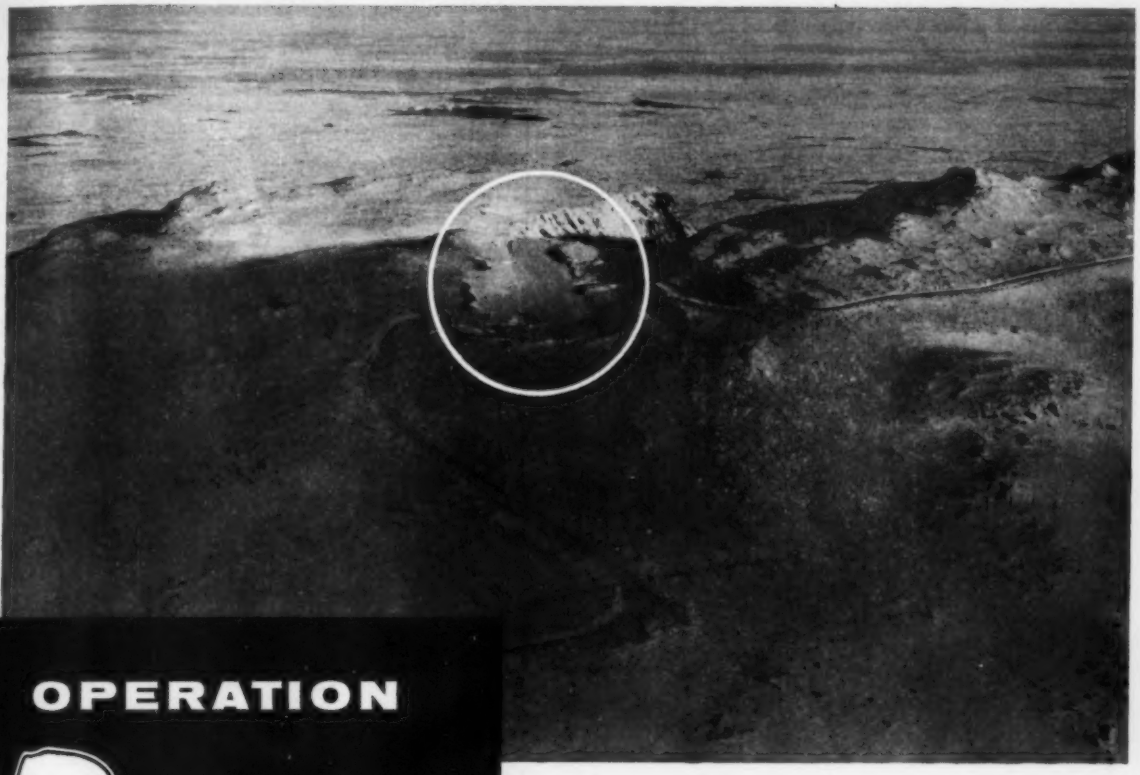
Titan 2 has a first stage lengthened by 10ft, and a second stage of the same diameter as the first. Propulsion by Aerojet-General shows no major change over that of Titan 1, apart from uprating and a number of important detail alterations. The propellants chosen are unsymmetrical dimethyl hydrazine and nitrogen tetroxide, which yield a specific impulse of about 262, compared with 280 for liquid oxygen/RP-1. On the other hand, they are indefinitely storable, and ignite hypergolically (without the need for an ignition system). Thrust rating of each chamber of the new first-stage engine is increased by one-third to 215,000lb, and the new second-stage engine has a rating of some 100,000lb in vacuum conditions.

An important detail of the new second-stage engine is that nearly all the expansion chamber —now of no less than 45 : 1 area ratio—is uncooled, the skirt being built up from asbestos tape, glass-fibre core honeycomb and epoxy or phenolic impregnated glasscloth. This has so reduced the size of the cooled portion that the steel basket-tubes of which it is constructed need not be filled with fuel until the engine is started above the atmosphere. Previously the entire chamber was filled with fuel before liftoff, causing system complications and creating an explosion hazard. This improved chamber is to be introduced to later Titan 1s. Propellant-transfer and supporting systems for Titan 2 are in production, and the hydrazine is being produced by an Air Force plant in Virginia operated by Olin Mathieson.

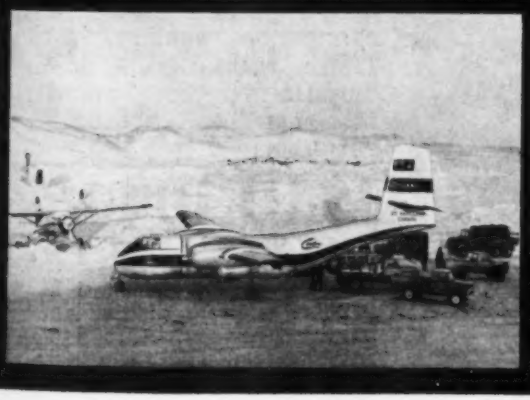
First flight of the enlarged missile could be this month. The silo to house it will be some 180ft deep, and will have a W-shaped exhaust deflector at its lower end to turn the first-stage flame round into ducts terminating at orifices flanking the silo mouth. A special silo launch test facility constructed at Vandenberg was used most successfully on May 3, when a Titan 1 J-Series missile was launched from the bottom and blown up when 140sec down the Pacific Missile Range (*Flight*, May 25, pages 688-9). Design of the new silo was assisted by model tests using Nike Ajax boost motors, and also by British work on the silo which would have been used by a military Blue Streak.

Titan 2 has been allocated to eight squadrons, each of which will have nine missiles deployed in individual silos. Pairs of squadrons will share common complexes, the locations being: Davis-Monthan AFB, Tucson, Arizona; McConnell AFB, Wichita, Kansas; Little Rock AFB, Arkansas; and Griffiss AFB, Rome, New York.

The total of 14 squadrons for both types of Titan will possibly be increased. Although Titan's one space role (booster for Dyna-Soar) may later demand the larger Saturn, Titan 2 is being held as a back-up to Atlas-Centaur for the Advent programme. Moreover, unofficial reports emphasize that the excellent circular-error figure of about 0.65 mile established by the first eight shots with inertial guidance may be allied with a very much larger warhead—and the trend is certainly towards increased yields, too heavy for Minuteman. It is even suggested that France and Germany could one day collaborate in operating an advanced version of Titan from the French Antilles; but it is not the function of this primarily technical survey to dwell on such things, "reliable" as the source may be.



OPERATION STOL



A SUPREME TEST OF CARIBOU TAKE-OFF AND LANDING PERFORMANCE . . .

Time: Midwinter 1961. **Place:** Resolution Island, above Lat. 60°N. **Operation:** 25,000 lb. of U.S.A.F. high priority freight to airlift from Frobisher. Round trip distance, 390 miles. **Carrier:** Nordair Limited.

Landing Strip: Length, 1300 feet. Width, not over 100 feet for half its length—walled in by banks of snow-covered rock 10 feet high. **Runway Extensions:** None. Sheer drop 800 feet, east end. Fall-off 300 feet west end.

Facilities: Strictly VFR.

Cross Wind: 25 kts., gusting to 30 kts., 60 to 90 degrees to the strip 70% of the time. **Turbulence:** Severe. **Average Temperature:** 24° below zero.

Operation Summary: MISSION ACCOMPLISHED.

The Caribou unloading at Resolution Island airstrip, which lies contained throughout its entire length within the circle (upper photo). Wheeler Airlines' Otter (background) uses the strip regularly.

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MISSILES 1961

Tactical

BLUE WATER

Ballistic artillery missile for mobile deployment

BRITISH ARMY

WHEN Corporal (*q.v.*) was adopted by the British Army in 1956, English Electric Aviation's guided weapons division at Stevenage, Herts, were appointed the foster-parents to introduce modifications and handle maintenance. This experience served them well in designing an entirely new weapon system to meet a 1958 War Office requirement for a "Corps-support weapon" to replace Corporal. The specification stipulated minimum and maximum ranges, complete air-portability, immunity to countermeasures, and minimum bulk, weight and cost.

Originally it was considered logical to design a special transporter/launcher vehicle, but during 1959 an even better solution manifested itself: the missile and launcher could be mounted on a standard 3-ton Bedford truck, on which could also be mounted all other equipment apart from a self-checking digital computer. The missile itself is of attractive design, and is only a fraction of the size of its contemporaries. Propulsion is provided by a high-impulse solid motor, and it is logical to assume that it must have boost and sustainer portions with different thrust levels. There is probably no need for thrust deflection, for complete control of the trajectory is provided by the cruciforms of fixed tail fins and moving wings. The latter are doubtless driven by a hydraulic control system according to signals from the self-contained inertial guidance system. The warhead is probably in the nose, and any weapon of this nature must be able to carry a variety of conventional or nuclear charges.

Under battlefield conditions the missile may be transported on its launcher or beneath a helicopter, ready to fire except for up to two fins or wings which can be attached in a few seconds. Missiles can be pulled on to the launcher by the latter's own movable jib and winch, and when the weapon is in place its umbilical connections are made with the fire-control equipment packaged in a saddle immediately beneath the launcher arm. When a target is located, the launcher is driven out of cover and roughly aligned facing away from the target. A theodolite is placed to one side, and the computer vehicle driven up on the other. Full instructions on trajectory, motor cutoff and warhead burst height are fed from the computer, while the theodolite accurately sets up the missile stable platform. The firing area is then cleared, except for the troop commander and his sergeant who respectively operate the warhead safety switch and arm the firing circuits. They double away with the firing box, switch the missile to internal power, wait until the launcher has elevated and then fire the missile.

In February last year the Minister of Defence announced the range of Blue Water to be "30 to 40-odd miles at the moment." A recent unofficial report claims that this is being increased to "the same as that of Sergeant, about 85 miles." The latter missile and Blue Water are major rivals for adoption by the NATO countries. No decision has yet been taken, although the British and West German Defence Ministers have held discussions on possible joint development of the missile. It remains to be seen whether the outstanding technical qualities of this weapon system can win NATO acceptance.

CAISSEUR

Cruise-type artillery missile

FRENCH ARMY

NO longer in service with the French Army except in isolated parts of North African colonies, the Sud 4200 and 4400 Caisseur is a ramjet-propelled miniature aeroplane with radio-command guidance. Details were contained in our 1959 review.

CORPORAL

Ballistic artillery missile for mobile deployment

US ARMY (*Surface/Surface Missile A-17*) AND BRITISH ARMY

DESCRIBED in the 1956 review, this slender 46ft weapon was the first large rocket missile to be developed after the German "V-2." It entered US Army service in 1953, and today two battalions are stationed in Italy, while 47 GW Regt of the Royal Artillery have fired missiles on the Hebrides range.

DAVY CROCKETT

Spin-stabilized nuclear rocket

US ARMY

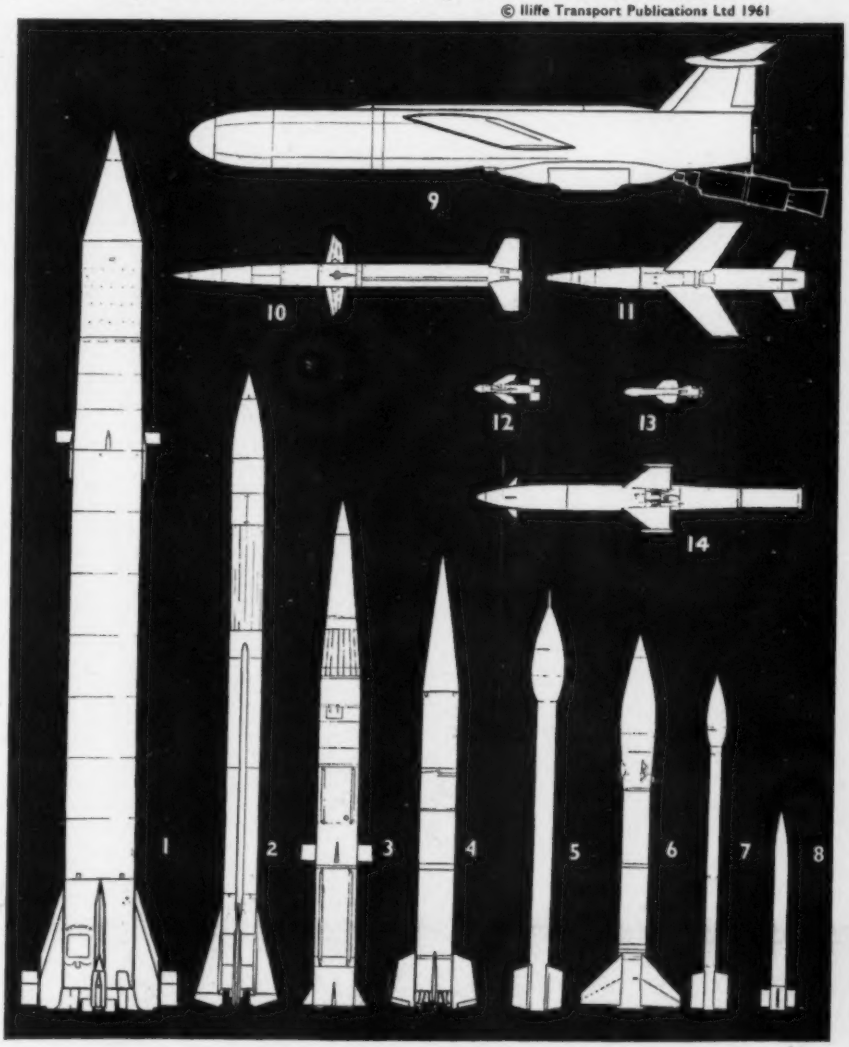
THIS missile has no guidance, but is launched from a tube set to the desired bearing and elevation. Two sizes of rocket launcher are available to cover a wide spread of ranges, and the smaller version enables the weapon to be carried by infantry. A sub-nominal (possibly 1kT) warhead is fitted, and the motor case is machined from a titanium tube. Development is directed by the US Army Rock Island Arsenal; it is overdue for operational service, and should be in the troop hands late next year. It has been announced by the US Department of Defense that Davy Crockett "will be available to the United Kingdom," warheads remaining in American hands.

HONEST JOHN

Spin-stabilized artillery rocket

US ARMY, AND ARMIES OF AT LEAST SEVEN OTHER COUNTRIES (*Surface/Surface Missile M-31*)

AT least 20,000 of these rockets are now deployed in many "Western" countries, the standard pattern having a 23in-diameter motor attached to a variety of 30in nuclear or conventional warheads. Prime contractors are Emerson Electric, who handle most of the manufacture under contract to the Army Ballistic Missile Agency (formerly to the Army



TACTICAL MISSILES: 1, Redstone; 2, Corporal; 3, Pershing; 4, Sergeant; 5, Russian artillery missile; 6, Honest John; 7, Russian artillery missile; 8, Little John; 9, TM-76B Mace (boost motor shown solid black); 10, Blue Water; 11, Lacrosse; 12, Tigercat; 13, Nord SS.12; 14, Robot 315

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TABLE 2: TACTICAL MISSILES

	Propulsion	Range (n.m.)	Launch wt (lb)	Length (ft)	Span (in)	Body diam (in)	Speed (m.p.h.)	Warhead
Blue Water	Solid rocket	50+	—	25	81	24	—	h.e. or N
Caisseur	Internal ramjet	55	2,200	11.5	118	—	605	551lb
Corporal	20,000lb RFNA+A rocket	74	11,500	46	84	30	2,300	h.e. or N (20kT?)
Honest John ...	Solid rocket	13	5,800	27.2	109	30	1,250	h.e. or N (20kT?)
Lacrosse	Solid rocket	17	2,300	19	108	20.5	800	h.e. or N (5kT?)
Little John	Solid rocket	5	760	14.5	23	12.5	1,000+	h.e.
TM-76B Mace ...	5,200lb turbojet	1,200	15,500	44.1	274	54	600	h.e., N or TN
Malaface	RFNA/Furaline rocket	22	3,500	20.7	—	—	600	1,000lb+
Matador	5,200lb turbojet	500	12,500	39.6	344	54	600	h.e. or N
Nord SS.12	Solid rocket	3.7	165	6.07	25.6	7.1	450	60lb?
Pershing	2-stage solid PU rocket	300+	30,000	34	—	39	3,000+	N (20kT?)
Redstone	75,000lb LO_2+alc. rocket	215	61,000	63	144	70	3,300	N (TN possible)
Robot 315	Resonant duct	10	3,000	24	84	—	600	1,000lb?
Sergeant	55,000lb solid rocket	74	10,000	35	71	31	2,300	h.e. or N (20kT?)
Tigercat	Solid rocket	—	—	4.82	25.6	7.5	—	h.e.

Rocket and Guided Missiles Agency), and Douglas Aircraft, who carried out the original design. ABMA have farmed out to industry the development of the M-50 version, which will have reduced dimensions and substantially increased performance.

LACROSSE

Guided artillery missile for mobile deployment

US ARMY AND CANADIAN ARMY (*Surface/Surface Missile A-12*)

AS outlined in our 1957 review, this hard-hitting battlefield weapon was originally intended for the US Marine Corps, but Cornell Aeronautical Laboratory and Johns Hopkins University continued development for the Army. Lacrosse consists of a light-alloy tubular body containing a Thiokol high-impulse solid motor and providing attachments for a guidance section, nuclear or conventional warheads, four large swept wings and four tail controls.

Provided its precise position is known, the target need not be visible, and can therefore be hit under all weather conditions or at night. Target location in daylight may be determined by the target ranging set, and other ground equipment (all transportable in Jeep-like vehicles) includes an angular tracker, computer, range/direction indicator and power unit. The dive on to the target is commanded by the launch crew, and the missile is officially termed the most accurate of all US Army surface-to-surface missiles. Examples of its accuracy include "a direct hit on a 2 × 4 stake from a range of more than 10 miles and destruction of a 4 × 8 target from a range of 19 miles." Produced by The Martin Company at Orlando, Florida, the missile equips at least eight battalions of the US Army, three of which are stationed in Germany and began firing trials at Grafenwöhr in September. Three years ago the Canadian Army announced their adoption of this weapon, for use both in Canada and Europe.

LITTLE JOHN

Spin-stabilized artillery missile

US ARMY (*Surface/Surface Missile M-51*)

THIS lightweight version of Honest John has been progressively developed "in house" by the Army Rocket and Guided Missile Agency (now Army Ballistic Missile Agency) at Redstone Arsenal since 1956. The original M-47 missile and M-32 launcher have been superseded by the M-51 rocket and M-34 launcher, which are lighter and cheaper and have superior performance. Chief contractors are Emerson Electric (airframe), Hercules Powder Co (two-stage motor) and Consolidated Western Steel (launcher). Development has been protracted, but the first battalion of four launchers will reach operational status next month. Reference should be made to Missile B, later in this section.

MACE

Subsonic-cruise bombardment missile for mobile or hardened deployment

US AIR FORCE, FRENCH AIR FORCE, JAPANESE AIR SELF-DEFENCE FORCE (*Tactical Missile 76*)

TWO versions of this pilotless bomber have been developed from the earlier Matador: TM-76A, with Goodyear Atran terrain-comparison guidance; and the TM-76B, with AChiever inertial guidance and considerably increased range. Built by Martin at Baltimore, both versions are in service with the US Air Force; the 38th Tactical Missile Wing has been operational with TM-76A since the summer of 1959, and two complete wings are to be equipped with the more effective B model. The first Mace B Wing is working up at Orlando AFB, Florida, and is destined for Okinawa. It is the intention of the Japanese Government to manufacture Mace B in Japan; one squadron of the French Air Force is to be equipped with the missile under the MDAP, but Mace will not now be bought by the Federal German Republic, who have chosen Pershing instead. Fuller details were given in our earlier reviews.

MALAFACE

Command-guided cruise-type bombardment missile

FRENCH NAVY

BASICALLY this weapon is a derivative of Malafon, described in the ASW section of this review. Instead of a parachute the rear of the fuselage is occupied by a small rocket motor which extends the range. Malaface is intended especially for crushing strong points during seaborne assaults.

MISSILE A

Lightweight artillery missile

US ARMY

DURING the past three years this designation has identified extensive design studies into a versatile short-range (up to 20 miles) weapon for battlefield use, replacing Honest John, Little John and Lacrosse. Feasibility studies have been completed at Redstone Arsenal, and component development has been in hand for more than a year.

MISSILE B

Lightweight artillery missile

US ARMY

THIS missile has not reached so advanced a stage as has Missile A, but the elements of the system have been completed. The range would be up to about 50 miles, yet the cost and complexity of the weapon should be less than one-tenth that of Corporal or Sergeant. Farther off in development are missiles C and D, which are intended to cover the complete Army spectrum of ranges out to well over 500 miles.

PERSHING

Selective-range ballistic missile for mobile deployment

US ARMY AND FEDERAL GERMAN ARMY

AS noted above, the US army hope ultimately to develop "Missile D" as the optimum missile system for use between ranges of about 80 and 800 miles. It would be a direct replacement of Pershing, and may very well be based on the latter's design. As a weapon system Pershing represents the best that could be done in the state-of-the-art existing in 1958, when the Wilson Memorandum forbidding the US Army any weapon with a range greater than 200 n.m. was rescinded. At that time the Army Ballistic Missile Agency were already well advanced with a specification and feasibility study, but management of the whole weapon system was in March 1958 placed with the Orlando Division of The Martin Company. This was the first time that the whole management of a new weapon was placed in the hands of private industry.

Compared with the earlier Redstone, which it replaces, Pershing is a much lighter and simpler system, fully air-portable by tactical transports and helicopters, and with drastically reduced reaction time. Tandem solid-propellant motors are by Thiokol, both stages having metal cases and single nozzles. Around the rear of each stage may be seen aerodynamic control surfaces spaced at 120°. The delta fins around the first stage are much smaller than the three wedge-section rectangles which assist in controlling the flight of the second stage, for the latter must work in near-vacuum conditions. Inertial guidance is by Bendix Eclipse-Pioneer, and the nuclear warhead is contained

Blue Water, the new corps-support guided missile for the British Army, is seen here on its transporter/launcher truck, following the larger and heavier vehicle which transports the unguided Honest John

within the large re-entry vehicle. The latter, which did not appear on the first test missiles, is protected during its hypersonic re-entry by a new type of ablative material developed by Martin's Baltimore Division in co-operation with the ABMA and Orlando Division. Varying thicknesses of thermal insulation are provided, and the finished cone is much lighter than earlier moulded patterns.

A Pershing battery is mounted on four M474 tracked vehicles, produced by Food Machinery Corporation, which each weigh 11,000lb. One carries the missile (minus warhead) on its transporter-erector-launcher, the second carries the warhead and azimuth-laying equipment, the third is the communications vehicle and the fourth houses the fire-control system and power pack. After the chosen warhead has been attached, the missile is raised vertically and lowered on to the simple ring launcher. Finally the transporter-erector-launcher lowers its arm and is removed, leaving the missile remote apart from the reusable umbilical mast.

Flight testing began on February 24, 1960, and extended-range missions with live second stages began last November. The second phase of the flight-test programme was completed in May, and during the last six months all tests down the Atlantic Missile Range have been made from the mobile ground-support equipment. Recent missions have investigated response to severe manœuvring commands, and accuracy over both short and long ranges. Total score to date is approximately 21 successes in 25 shots.

Several recent firings have been over ranges of the order of 250 n.m. The design range is said to vary up to at least 500 n.m., and the NATO Military Committee are showing interest in extended-range Pershings for general use in Western Europe. Initial operational capability with Field Artillery Missile Groups of the US Army is expected in a matter of weeks. The Federal Republic of Germany decided in May of this year to purchase Pershing in place of the earlier Mace (*q.v.*), and unofficial reports suggest that at least 60 will be bought at a cost of some £43m.

REDSTONE

Selective-range artillery missile

US ARMY (*Surface/Surface Missile A-14*)

FIRST missile of its size and performance, Redstone was produced at the Redstone Arsenal largely by the team of former German scientists who had worked on "V-2." Operational since 1956, the missile was described in *Flight* for May 23, 1958.

ROBOT 315

Air-breathing bombardment missile for shipboard use

ROYAL SWEDISH NAVY

SEA trials of this weapon began in April 1955, and the missile has for three years formed part of the armament of two destroyers. Details were given in the 1957 review.

SERGEANT

Tactical ballistic missile for mobile deployment

US ARMY

TEN years ago, when Corporal was under intensive development, it was realized that a second-generation weapon system could be produced which would be vastly improved from the viewpoints of system complexity and reaction time. After four years of study the Army authorized the Sergeant programme in January 1955. The development contract went to Jet Propulsion Laboratory, under the supervision of Redstone Arsenal, and Sperry were brought in as prime manufacturer. The Sperry Rand Corporation built a new plant at Salt Lake City and established the Sperry Utah Company to manage the work. The latter company became prime contractor when JPL were transferred to NASA last year.

Diameter of Sergeant is one inch greater than that of Corporal, but it is 11ft shorter and roughly 1,000lb lighter. For transport purposes the missile is divided into warhead, guidance, motor (all housed in sealed cylindrical containers) and the four control surfaces. The ground-support equipment consists of a launching station, organizational maintenance test station and field maintenance test station, each carried on articulated trailers with three-axle tugs, and truck-mounted communications. To engage a target the convoy pulls off the road, the generator is started, the launcher levelled and the launcher boom unfolded to provide a girder beneath which the missile may be assembled. Reaction time is 30min, and launch takes place at an elevation of 75°. Trajectory is controlled by the four tail surfaces, with vanes projecting into the jet from the Thiokol M53 polysulphide motor. No provision is made for thrust termination, range being determined by timing the opening of air brakes around the rear of the guidance section.

During the past two years Sperry Utah have received more than $46m for industrial production of the system, and research and development firings ended with a fully successful test under battlefield conditions at White Sands on September 28. Courses for future instructors and maintenance personnel began in January, delivery of inventory equipment started in March, and the first class of artillerymen graduated in April. Future firings will be conducted by user troops "for proof of characteristics, to check the quality of line-produced missiles and to train combat units." A small evaluation quantity of Sergeants has been ordered for the West German army, but at the time of writing it is impossible to say whether Sergeant or the Blue Water—better but later in development—will become a standard NATO weapon.

SHILLELAGH

Multi-purpose weapon for vehicle mounting

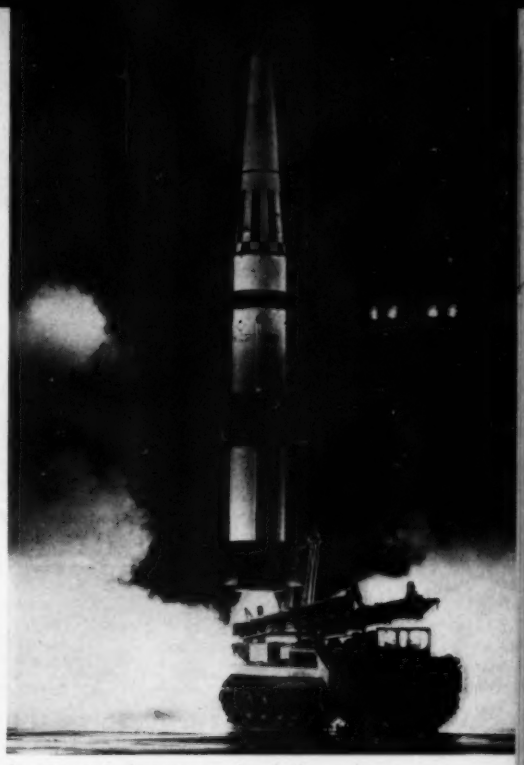
US ARMY

SHILLELAGH is described as "a new surface-to-surface guided missile being developed for close support of front-line troops." Combining simplicity of operation with reliability and lethality, it is said greatly to increase fire-power against infantry, field fortifications and armour, and, with microwave command guidance, to have accuracy sufficient for first-round kill probability against stationary or moving targets. The initial development contract was awarded to the Aeronutronic Division of Ford Motor Company in 1959, tactical development and technical direction being the respective responsibility of the Ordnance Tank Automotive Command and Redstone Arsenal.

Subcontractors include: Raytheon, fire-control system; Genisco, accelerometer; Telecomputing Corp (Whitaker Gyro Division), two-axis free gyro. Elvis Stahr, Secretary of the Army, recently said "$23.5m is provided for the development of the ARAAV (armoured - reconnaissance/airborne - assault vehicle) and the Shillelagh guided-missile system with which it is to be armed. This will provide a highly mobile and lethal anti-tank capability against the heaviest known armour." His Assistant Secretary for Research and Development said recently "The Shillelagh combat vehicle weapon system with gun-launcher is new in virtually every respect." The weapon is expected to become operational in about four years.

SOVIET MISSILES

FOR more than 20 years the Red Army has been famed for its rocket weapons. Currently



Largest and longest-ranged missile under development for any army outside the Soviet Union, Pershing is seen here during a night firing from Cape Canaveral. The transporter-erector-launcher can be clearly seen

in the inventory may be found every species from the simplest rocket launched in salvo up to large ballistic missiles. The drawings on page 703 were prepared from photographs taken during ceremonial parades through Red Square, Moscow, and longer-range missiles are depicted on page 697. Readers may draw their own conclusions from the appearance of these weapons; those with bulged warheads are clearly spin-stabilized missiles akin to Honest John, and are said to be designated "T-5B, T-5C," etc.

SS.12

Wire-guided bombardment missile for mobile deployment

FRENCH ARMY

DRAWING upon their experience with SS.10 and SS.11 (page 718), Nord-Aviation have evolved this weapon to provide a multi-purpose bombardment missile with substantially increased range and striking power. It is fired from a simple launcher placed either on the ground or a vehicle, and is already mounted on this launcher inside its transit case. Ground equipment is identical with that for SS.10 and SS.11, and the arrangement of two-stage solid motor, vibrating jet spoilers, tracking flares and guidance wires closely follows SS.11 practice. The "pre-series" have given encouraging results, and production for inventory service is scheduled to begin next year. The same missile has been modified for air-launching, under the designation AS.12 (*q.v.*).

TIGERCAT

Guided missile for mobile deployment

PRIVATE VENTURE

NOTHING has recently been heard of this land-based derivative of Seacat 1, apart from models of possible methods of deployment exhibited at the Paris Salon in June. Various arrangements of multiple launcher and radar guidance have been investigated, for use by mobile troops against battlefield targets and aircraft.

A superb portrait of an Avro Vulcan B.2 of RAF Bomber Command armed with an Avro Blue Steel missile

Air-to-Surface

BLUE STEEL

Strategic rocket-propelled cruise missile

ROYAL AIR FORCE

DURING the past four years the Weapons Research Division of A. V. Roe & Company Ltd, at Woodford, Cheshire, have held the prime contract for this "stand-off bomb," which is designed to be carried by V-bombers to improve their penetrative ability and enable them to deter for several years longer. Possibly influenced by the unsuccessful GAM-63 Rascal, its designers have produced a canard with delta aerodynamic surfaces and a fat body housing liquid propellants for a rocket powerplant. The airframe is largely of stainless-steel honeycomb, which may well permit supersonic speeds to be maintained at low altitudes. Propulsion is provided by a Bristol Siddeley Stentor, fed by turbopump with HTP and kerosine. This engine has superimposed thrust chambers of unequal size, with sea-level ratings estimated to be approximately 16,000lb and 4,000lb.

Carrier aircraft are the Victor B.2 and Vulcan B.2, each of which can carry a single Blue Steel beneath the centreline. Chief contractor for missile guidance is Elliott Brothers (London) Ltd, and the system is at least partly of an inertial nature. The bomber carries an AEI digital mission computer, and its navigation and fire-control systems are linked to the missile up to the moment of release. Blue Steel need not fly a direct course, and may also make sudden changes in altitude or take evasive action. Manœuvres are effected by twist-and-steer, the missile being rolled by ailerons on the trailing edge of the wing and then pulled round in a turn by the foreplanes. Directional control is provided by a dorsal fin and rudder, and a larger ventral fin which folds to port to provide adequate ground clearance beneath the aircraft.

At the recent SBAC Show the prime contractor, ML Aviation, and No 4 Joint Services Trials Unit (based at Woodford) jointly displayed the ground-handling system. Blue Steel is carried on a vehicle based on the AEC Matador chassis, incorporating gear reminiscent of lifeboat davits for lowering the missile on to its hydraulic loading trolley. The latter holds it close to the ground, and incorporates front and rear cradles for lifting the missile up against the crutch pads of the carrier aircraft. Operational service is scheduled for 1962.

BULLPUP

Radio-command tactical missile

US NAVY (*Air/Surface Missile N-7*), US AIR FORCE (*Guided Air Missile 83*)

ORIGINALLY the Navy's Bullpup was little more than a 250lb bomb fitted with propulsion and a command control system, developed to enable small carrier-based aircraft to achieve pinpoint accuracy against heavily defended ground targets. So effective and popular has the missile become that Martin's Orlando Division are developing a range of larger and more effective weapons. Details of the first-generation N-7 have been given in our previous reviews, and data are given in Table 3. These missiles are fired by all kinds of aircraft, from the Navy HUS-1 helicopter to the 1,400 m.p.h. F-105 of Tactical Air Command. Recent improvements have led to the Navy N-7A (improved h.e. warhead, extended-range control and pre-packed liquid motor) and Air Force GAM-83A (modified radio command to permit firing from an offset position). A TGAM-83 trainer version is also in use.

Development is now centred upon the Bullpup B, or N-7B, for the Navy. This version has interchangeable nuclear or conventional warheads, a further improved guidance system, a fatter body to house the larger motor and warhead, and enlarged wings to handle the greater weight. Intensive trials are being flown by Grumman A2Fs (five missiles) and Douglas A4Ds (three), and second-source production by Maxson Electronics is to begin in 1963. A different, nuclear-head GAM-83B version is being developed for the Air Force.

HOUND DOG

Strategic turbojet-propelled cruise missile

US AIR FORCE (*Weapon System 131B, Guided Air Missile 77*)

WHEN the vast WS-104 (SM-64) Navaho programme was cancelled in 1957 the vacuum left at North American Aviation's Missile Division (now Space and Information Systems Division) at Downey, California, was filled by award of the prime contract for the development of WS-131B. This was to be a long-range missile which could be carried by the heavy bombers of Strategic Air Command and used to deliver nuclear payloads against major targets. The need for such a missile was accentuated by the steady improvement in the ability of the potential enemy to destroy manned aircraft. Penetrative capability of SAC's earlier missile, the rocket-propelled Rascal, was inadequate. North American had to develop a vehicle able to cruise at high supersonic speed over a range of 500 miles, with minimum penalty incurred by cruising at various heights down to sea level.

Six months after receiving the contract in August 1957, NAA had built a mock-up missile, revealing a canard (tailplane-first) configuration, delta wing, slender body and underslung Pratt & Whitney J52 turbojet. The latter, fed by kerosine occupying most of the fuselage, has a plug-type nozzle and a fully variable multi-shock intake with a centre-body cone positioned by a Marquardt control system.

Sole carrier of GAM-77 and the improved GAM-77A Hound Dog is the Boeing B-52G, which has pylons for a missile beneath each wing. When released from the bomber the missile knows how to reach its target without external assistance, notwithstanding the fact that it may be programmed to swoop "under the radar," climb to extreme altitudes before diving almost vertically on to its target, or fly zig-zag courses. Guidance, by the prime contractor's Autonetics Division, is monitored by an automatic star-tracker, which feeds position information into the inertial auto-navigator and Verdan digital computer. Missile manœuvre is by twist-and-steer, with ailerons, foreplane and rudder.

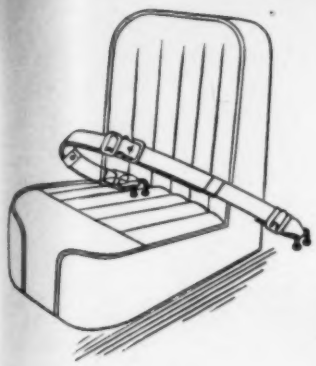
Flight testing has been based at the Eglin Gulf Test Range, although some Hound Dogs (including one which before launch had been carried on a non-stop 10,800-mile flight over the North Pole) have been successfully fired down the Atlantic Missile Range. The first powered example flew in April 1959, and the first production GAM-77 followed in March 1960. During the latter month the 4135th SAC Wing was equipped with the missile, and the 4241st and other Wings have since become operational. Deliveries to SAC of the GAM-77A are about to begin.

NORD 5110 (AS.20)

Radio-command tactical missile

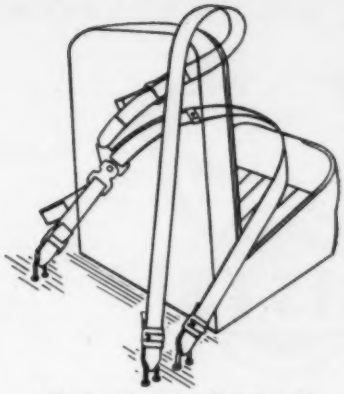
FRENCH AIR FORCE, FRENCH NAVY, FEDERAL GERMAN AIR FORCE, ITALIAN AIR FORCE (*Air/Surface Missile 20*)

DERIVED directly from the Nord 5103 (AA.20), the AS.20 is limited in employment by the fact that it must be steered to its target by an operator in the launch aircraft, who must keep the missile and target aligned visually up to the moment of impact. Its advantages are that the overall system is relatively cheap and simple, can be readily applied to any military aeroplane and can be used against almost any kind of target on the surface or in



Type A. Lap Strap in Grey or Crimson

We manufacture Survival



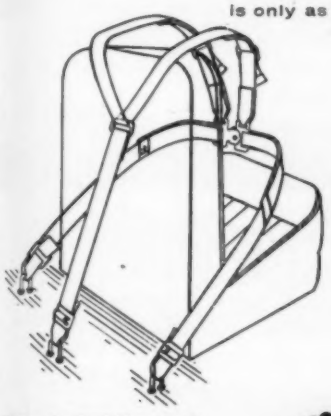
Type B. Lap Strap and Diagonal Harness in Grey or Crimson

When Bluebird crashed at more than 300 MPH during an attempt on the World Land Speed Record, Donald Campbell attributed his survival to the type Z safety harness that he was wearing at the time. The harness was designed by the G. Q. Parachute Company Ltd. in collaboration with the Mechanical Engineering Department of the Royal Aircraft Establishment, and the Royal Air Force Institute of Aviation Medicine.

The type Z is now being fitted in increasing numbers to high performance cars in both front and rear seats, and to meet the demand for a lighter and less expensive harness, G. Q. are now producing a new range of properly engineered car harnesses which are shown on this page.

The full harness with two shoulder straps undoubtedly gives the best possible protection, while the lap strap and diagonal harness is essentially a compromise in which some efficiency is lost in exchange for more freedom of the upper part of the body and less leg room obstruction near the back seats. The lap strap should only be used where the head or body of the wearer in a jacknifed position cannot strike any solid obstruction.

There are many accidents in which a well-designed safety harness will save life, but it is essential to remember that a safety harness is only as good as the structure to which it is attached.



Type C. Full Harness in Grey or Crimson

A special quick fitting version of the type B harness has been developed for use in fire engines, ambulances, and other vehicles where rapid "take-off" is vital. Illustrated literature and data sheets for all other G.Q. aircraft and vehicle safety harness are available on application.

Type Z. (Special) Full Harness in Blue, Grey or Crimson

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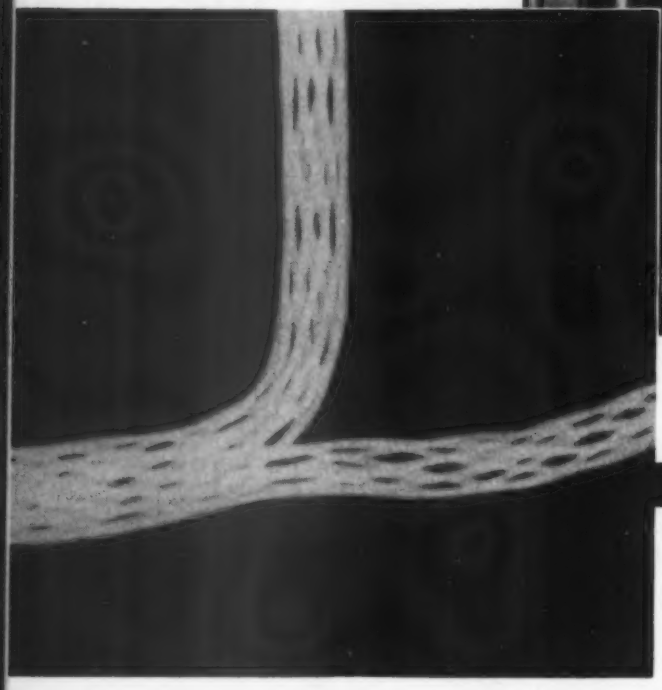

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the air. Compared with the original air-to-air weapon, AS.20 differs in not having a proximity fuze, and the extra space is utilized by the increased size of the variety of warheads which may be fitted. It is reported that there is an air-to-surface version of the radar-guided AA.25, but this could be employed only against ships, or similarly clear radar targets.

NORD 5401 (AS.30)

Radio-command tactical missile

FRENCH AIR FORCE, *and most* NATO *nations* (*Air/Surface Missile 30*)

COMMERCIAL success has come to Nord Aviation through their policy of producing usable and wanted guided weapons earlier than their rivals. These weapons have, in time, become technologically outmoded; but the score of 72,000 rounds delivered—partly on a private-venture basis—speaks for itself. It is a remarkable fact that no European country, and the United Kingdom in particular, has developed a hard-hitting guided missile for use from any type of aeroplane against any type of surface target. Nord's AS.30 can be launched from a helicopter or from an aircraft travelling at supersonic speed, and its size is adequate for it to carry a nominal nuclear warhead (although such a device has not yet been produced in France).

Ancestry is obvious; the missile is essentially a scaled-up AS.20, with a higher wing loading, increased velocity and choice of visual or radar guidance. Steering is accomplished by biassing the vibrations of the trembler spoilers which intermittently interrupt the twin jets from the sustainer motor. Trials at Colomb-Béchar and Cazaux have been conducted principally with Canberras and Vautours, and satisfactory results have been obtained. Competition with Bullpup for NATO acceptance has been intense, and at the time of writing it seems likely that the French missile will win. Whatever the outcome of the competition may be, the winner is almost certain to be adopted by the RAF and Royal Navy. Carriers already announced for AS.30 include the Mirage IIIE and Etendard IVM.

QUAIL

Bomber-protection decoy

US AIR FORCE (*Guided Air Missile 72*)

NOT strictly a missile, for the reason that it is not meant to hit anything, Quail is designed to confuse rather than destroy. Developed by McDonnell Aircraft, and first flown in 1958, it is a miniature aeroplane constructed largely of reinforced plastics and powered by a GE J85 turbojet. Carried in the bomb bay of a B-52 heavy bomber, Quail is released as defended enemy areas are approached. The wings and fins unfold and the vehicle thereafter operates electronic and possibly other types of countermeasures in order to dilute the enemy defensive effort.

ROBOT 304

Radio-command tactical missile

ROYAL SWEDISH AIR FORCE

TAILORED for carriage by the Saab A32A Lansen attack aircraft, Rb304 was in preliminary design 11 years ago and flew in 1955. Features include a two-stage solid motor, a rear wing with tip fins incorporating tracking flares, and cruciform nose controls operated by the electro-pneumatic XA82 autopilot.

SKYBOLT

Hypersonic ballistic missile

US AIR FORCE (*Weapon System 138A, Guided Air Missile 87A*), ROYAL AIR FORCE

MANNED bombers have become exceedingly vulnerable. Even aircraft capable of coming in at supersonic speed "on the deck," or at 2,000 m.p.h. at 70,000ft or more while packed with countermeasures, can no longer live in a modern missile environment. The penetrative ability of a missile like Blue Steel or Hound Dog is considerably better, owing to its much smaller radar cross-section and very high performance; but by 1957 it appeared that an even better answer was the marriage of the bomber and the ballistic missile. Such a combination would be an excellent Cold War deterrent, for the launch aircraft could maintain standing patrol just outside the frontier of the presumed enemy; while in an all-out conflict the ALBM (air-launched ballistic missile) would have all the advantages of the ballistic missile's extreme speed and relatively small re-entry vehicle, coupled with the fact that its launching site could be almost anywhere in the world.

The feasibility of launching large ballistic vehicles from bombers travelling at both subsonic and supersonic speeds was demonstrated to the US Air Force by several con-

AIR-TO-SURFACE MISSILES: 1, GAM-87A Skybolt; 2, Nord AS.20; 3, Robot 304; 4, GAM-77A Hound Dog; 5, Russian missile carried by Badger medium bomber; 6, Nord AS.30; 7, Bullpup B; 8, Bullpup; 9, Blue Steel; 10, Russian missile carried by "Yak-25 development"; 11, Russian missile carried by so-called "Beauty" supersonic bomber; 12, GAM-72 Quail; 13, Russian missile carried by Bear heavy bomber

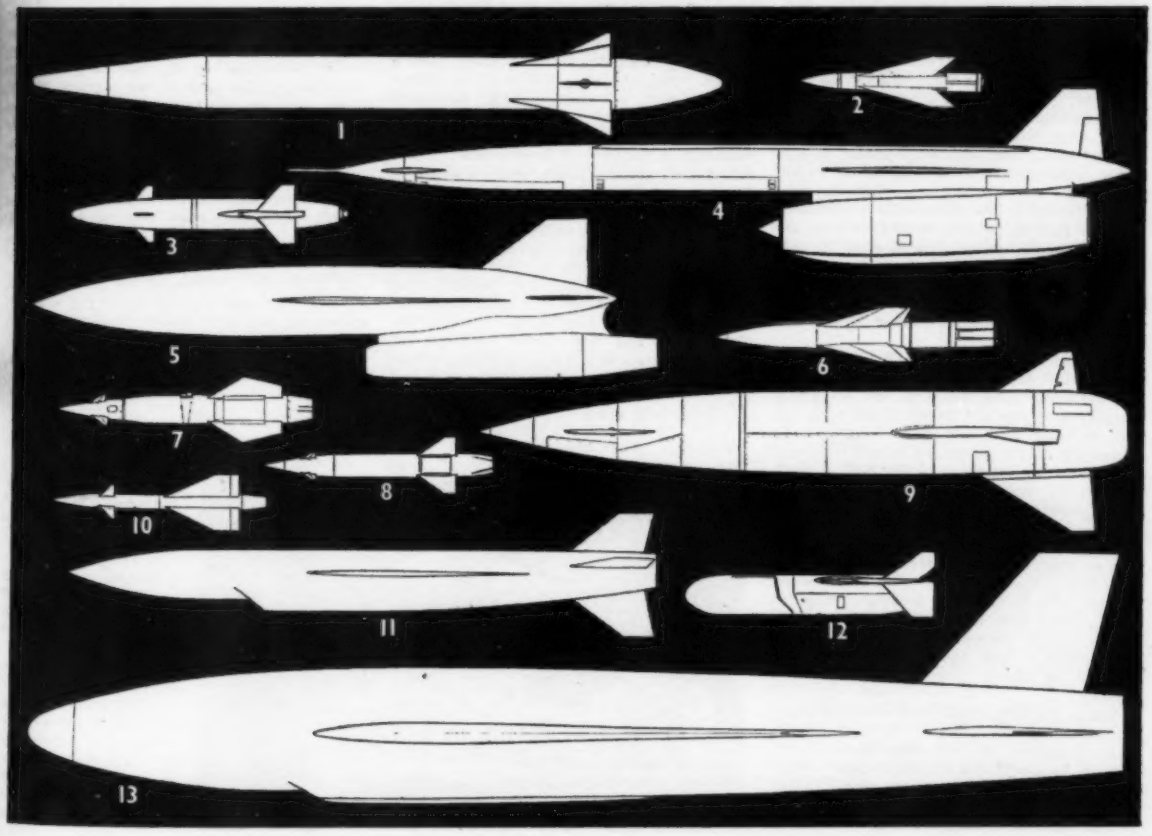


TABLE 3: AIR-TO-SURFACE MISSILES

	Propulsion		Length (ft)	Span (ft)	Body diam (in)	Launch wt (lb)	Range (n.m.)	Mach number	Warhead
	Type	Propellant							
Blue Steel I	Stentor rocket	HTP+K	35	13	50	15,000?	300?	2?	TN (4MT?)
ASM-N-7 Bullpup	Rocket	Storable liquid	10.5	3.1	12	571	3	2.4	250lb
GAM-83B Bullpup	Rocket	—	—	—	12	750+	5+	2+	N (10kT)
GAM-77 Hound Dog	J52 turbojet	K	42.5	12.1	28	9,600	435+	1.6	TN (4MT)
Nord AS.20	2-stage rocket	Cordite-type	8.5	2.6	9.84	309	3	1.7	73lb
Nord AS.30	2-stage rocket	Solid	12.4	3.3	13.4	1,125	6	2	505lb or N
GAM-72 Quail	J85 turbojet	JP-4	12.8	5.4	25	1,100	200	0.9	n.a.
Robot 304	2-stage rocket	Solid	14.75	6.7	19.4	1,200	3+	1	550lb
GAM-87A Skybolt	2-stage rocket	PU/AP	38	n.a.	35	11,300	1,000	9	TN (2MT)

tractors in 1958, and when specific design proposals were requested in 1959 Douglas Aircraft received a further contract to continue to study WS-138A. Before the year was out Douglas had awarded subcontracts to Aerojet-General for propulsion, General Electric for the re-entry vehicle and Northrop Nortronics Division for missile guidance. Douglas were awarded the prime contract for WS-138A in February 1960, and the programme has since moved on schedule.

At an early stage it was agreed that the principal carrier aircraft would be the Boeing B-52; the B-52H has been specially designed to carry this weapon system, and the B-52G and earlier versions can be adapted with modification. In April 1960 the British Minister of Defence announced that, Blue Streak having been cancelled, the British nuclear deterrent would be delivered by this system, and that he was negotiating for its purchase for RAF Bomber Command. In the latter service the carrier aircraft will be the Vulcan B.2. As reported in *Flight* of September 30, 1960, Douglas had studied the Victor as a carrier aircraft and found that "the installation problems would have been more severe, mainly because of ground clearance." Studies were also made of the Boeing KC-135, but the B-58 was not considered, and the planned B-70 posed kinetic-heating and separation problems.

Missile portion of WS-138A is GAM-87A Skybolt. The arduous structural design case of having to withstand flight manœuvres and (possibly) landing impacts, while suspended in a horizontal position from points along the upper edge, dictated a rigid airframe constructed along lines somewhat similar to the larger Minuteman. Two propulsion stages were found to be the optimum. Both contain a Polaris-type polyurethane-base propellant, which is kept at uniform temperature by an electric heating system operative up to the moment of release. Trajectory control is effected by swivelling second-stage nozzles, and the nozzle of the first stage is faired over until shortly after missile release by a drag-reducing tailcone.

Designed by Douglas, the B-52 pylon is bifurcated to carry two missiles (four or eight per aircraft). The weapons are staggered laterally to follow the sweep of the wing, to give minimum drag, and improve separation. During the outward flight the aircraft bombing and navigation system is continuously linked through the pre-launch computer to the guidance computer in the missile, and thence to the missile guidance system. In view of the brief flight time it is surprising that the inertial system requires stellar monitoring, but (as described in last year's review) a star-tracker is fitted with its telescope looking through a circular dark area 13ft from the nose of the missile. In fact, the star-tracker in each missile is probably a "belt and braces" method of determining launch position sufficiently accurately.

Missile trajectory starts with a free fall from the launch aircraft. The tail fairing is explosively jettisoned, the first-stage motor fired, and the missile pulled up into a climb—with or without a change in heading—ahead of the launch aircraft. Flight stability is improved by the eight delta fins, the four of reduced chord apparently being used to control the initial pull up into a climb and roll the missile through 180°. After stage-separation, the second-stage engine is fired, providing for precise trajectory control and thrust termination in order to place the re-entry vehicle on the desired ballistic trajectory. It will be noted that the final re-entry vehicle blends smoothly into the main missile body, like that of Jupiter; it is an entirely new ablative model, shorter and lighter than the original schemes reminiscent of the Mk 3 and Mk 4 re-entry vehicles of the ICBMs.

During the past year compatibility between WS-138A and the B-52H and Vulcan B.2 has been proved in all details. Dummy missiles were flown from Boeing's Wichita plant beneath a B-52G development aircraft on January 12, and the first drop tests of inert missiles were made over the Eglin Gulf Range in March. Vulcan B.2 compatibility tests began with a two-day electrical and electronic examination in Los Angeles in February, and were completed at Edwards AFB in July. It was then announced that "great progress" had been made in matching the missile to the Vulcan's bomb-nav system by means of relatively simple electronic circuits. The British aircraft carries one missile beneath each wing and in recent weeks has been seen so equipped over Britain.

At the time of writing, live firings down the Eglin Gulf Range are imminent, followed by full-range firings down the Atlantic Missile Range. Douglas have taken pains to restrict state-of-the-art advances in order to ensure that development proceeds on schedule; but financial juggling in Washington has led to a reduction in the pace of development. Funds for major subcontractors were slashed in January, and during Congressional Testimony in June the Director of Research and Engineering at the Department of Defense, Dr Herbert York, said that investigations by the Kennedy administration had shown that the $150m appropriated for WS-138A research and development before they took office would not suffice to carry the programme through 1961. Some $50m had been added, although the 1962 programme is still to be partially funded by money voted in 1961. Initial operational capability is scheduled for 1964 with SAC and 1965 with the RAF, but Dr York said recently "The Skybolt will be available at a later date . . . than it would be under a programme where the principle of concurrency was fully applied."

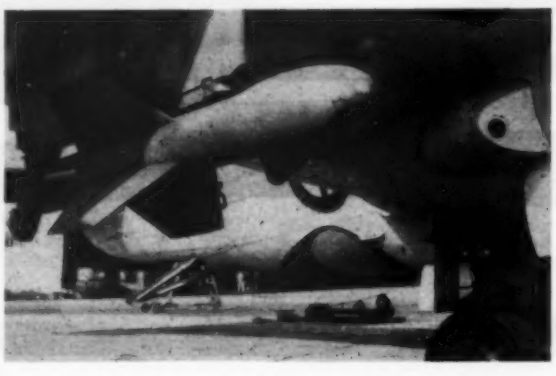
SOVIET MISSILES

OUR five previous reviews of the world's guided weapons have included not a word about Russian missiles launched from aircraft. Nothing was publicly known of such weapons outside the Soviet Union until the air display at Tushino last July 9, when no fewer than eight types of missile were seen matched to at least nine types of aircraft. Three of these missiles are portrayed in the Air-to-Air section of this review; one is a rocket used for ground attack by the new Kamov turbine-powered co-axial helicopter, and pictorial information is inadequate for us to attempt to draw it here; the other four missiles are included in the drawings on page 707.

By far the largest missile ever matched to an aeroplane is a 58ft weapon (sketch 13) carried beneath the fuselage of the Bear turboprop bomber. The wing is similar to that of the Fitter supersonic fighter; but, apart from the facts that the nose appears to house a radar, there is a ventral air intake and a very large propelling nozzle and that the cruising speed is probably about M2, little can be deduced. When converted to carry the missile the bomber has its nose filled with radar. So does the medium bomber Badger, the weapon for which (sketch 5) has an underslung package containing either one or two engines, and a range of some 300 miles. Drawing 11 is the M3 missile carried partially submerged beneath the new supersonic bomber known in the West as Beauty; propulsion is probably by a ramjet. Drawing 10 is a missile, carried beneath the wings of a Yak-25 development, which may equally serve in the air-to-air role.

WAGTAIL

ALTHOUGH a victim of the economy axe of 1957, this missile is still proving of singular technical interest. Under development by Minneapolis-Honeywell for the Air Force, Wagtail was designed for rearwards launching from a high-speed, low-level aircraft. The technique is now being investigated for ALBM and air-to-air missions.



Nord AS.12 carried by Breguet Alizé ASW and attack aircraft of the French Navy. This missile has radio guidance, in contrast to the wire guidance of the land-based SS.12

Surface-to-Air

The US Army's Nike Zeus anti-missile weapon system is of incredible size and performance. Here a Zeus test vehicle is being assembled at White Sands

BLOODHOUND

Radar-homing weapon for area defence

ROYAL AIR FORCE, ROYAL AUSTRALIAN AIR FORCE, ROYAL SWEDISH AIR FORCE, AND SWISS FEDERAL FORCES

OUTSIDE the USA and Soviet Union, Bloodhound has been the subject of the world's largest guided-weapon programme. Originally developed under the code-name of Red Duster, the system comprises high-power three-dimensional tracking radars by Metropolitan-Vickers, Sting-Ray target-illuminating radars by AEI, and a missile developed jointly by Bristol Aircraft and Ferranti Ltd and propelled by a pair of Bristol Siddeley Thor ramjets. The missile manœuvres by twist-and-steer from a single pair of moving wings, and its guidance computer causes it to fly a proportional-navigational course. When within lethal distance the proximity fuze detonates the warhead, which in later missiles has been officially stated to be of a nuclear type.

Bloodhound Mk 1 is now serving in Fire Units of 16 with RAF Air Defence Missile Squadrons protecting V-bomber or Thor bases in several parts of the British Isles, and has also been evaluated by the Royal Swedish Air Board and ordered by the RAAF. The system has been fully described in past issues, notably those of October 23 and November 7, 1959. It has now been superseded in development by Bloodhound Mk 2. Although deriving directly from the earlier weapon system, Bloodhound 2 embodies both the considerable experience gained with Bloodhound 1 in addition to the many technological advances made since the design of Bloodhound 1 was finalized.

As discussed in *Flight* for September 16, 1960, the greatest single advance made with the new weapon is the use of continuous-wave guidance. In addition to enabling Bloodhound's radar range to be extended, the adoption of CW radar has made it possible to achieve great lethality against all types of target down to very low altitudes, even in the face of highly sophisticated countermeasures. Commensurate advances have been made in the ground radar equipment, and the Bloodhound 2 radar is the most accurate and advanced radar set known. Cruise propulsion is provided by a new and more advanced version of the Thor ramjet, which gives even better range and altitude performance. Improvements have been made in the various sub-systems of the missile, and full advantage has been taken of developments in design and manufacturing techniques to increase efficiency, reliability and serviceability. The launch control post, for example, is built around a compact and highly reliable digital computer, with a consequent gain in speed of response and flexibility of operation.

All the radars, electronic equipment and other elements of the Bloodhound 2 system have already completed arduous test programmes. Development firings have included a substantial number against jet targets flying at altitudes well under 1,000ft. These firing trials have proved outstandingly successful. Bloodhound 2, which is fully air-transportable and so is capable of rapid deployment overseas, is on order for the Royal Air Force. It has also been ordered by the Royal Swedish Air Board for the primary defence of Sweden and has been recommended for adoption for the defence of Switzerland by the Swiss Federal Council. Both Sweden and Switzerland are nations uncommitted by external treaty obligations, and so able to base their selection of defence equipment solely on the technical and operational merit of available weapons. Both made their choice after long and careful appraisal of all available missile systems. At the time of its announcement on July 6, the Swedish order was by far the largest ever placed for a British missile system by an overseas government. The order from Switzerland is likely to be even larger, being expected to total between £25m and £30m. Such orders have been facilitated by the ability of the weapon-system team to offer a complete "package deal"; and by the lethality, speed of reaction and flexibility of operation of the Bloodhound 2 system itself.

BOMARC

Radar-homing weapon for area defence

US AIR FORCE (*Intercepter Missile 99*), ROYAL CANADIAN AIR FORCE

LARGER and heavier than many jet fighters, Bomarc is fired vertically under the thrust of a boost rocket in the tail. During the climb the two Marquardt RJ43 sustainer ramjets are lit, and take over for the remainder of the climb to the preset cruise altitude. Mid-course guidance is effected by SAGE (semi-automatic ground environment) electronic command, and terminal homing guidance is a fully-active radar system by Westinghouse. Proximity fuzes detonate the conventional or nuclear warhead.

First pre-production IM-99A rolled out from the Seattle plant of Boeing Airplane (now The Boeing Company) at the end of 1957. This version of the missile has a range (Table 4) sufficient for it to protect 125,000 sq miles. It is launched by a non-jettisonable rocket burning a storable kerosine and red fuming nitric acid, and the RJ43-3 ramjets burn 80-octane petrol. Following extensive tests from Santa Rosa Island down the Eglin Gulf Range Bomarc A became operational last year, and all five bases are now in service; McGuire AFB, Trenton, New Jersey; Suffolk AFB, New York; Otis AFB, Falmouth, Massachusetts; Dow AFB, Maine; and Langley AFB, Hampton, Virginia. At each are stored 28 or 56 missiles at almost instant readiness, each in a shelter with split roof halves which open in 5sec even under a 25-ton load of snow.

Now being delivered is IM-99B, the apparent similarity of which to Bomarc A belies its very great increase in performance. Almost the only superficial difference is that, whereas the Bomarc A's engines, in Boeing's words, "remind one of a corseted Gay Nineties belle," the RJ43-7s of Bomarc B run straight out to their large propelling nozzles; a technician would also note that the intake centrebody is set for a higher Mach number. These new engines are substantially more efficient and powerful, and burn JP-4 kerosine with an added corrosion-inhibitor. Another major change is the switch to a jettisonable Thiokol solid-propellant booster, and the additional body space is occupied by extra ramjet fuel. The fin is redesigned, incorporates more magnesium, and is 29 per cent lighter, contributing to a final airframe weight 65lb under that of Bomarc A; electric batteries are replaced by a monofuel turboalternator; and the remarkable target seeker has very great discrimination between true targets and decoys.

Flight trials of Bomarc B began in mid-1959, and technical difficulties, chiefly with sustainer propulsion, prevented any of the first seven missiles from completing their missions. Things improved, and the experimental programme was completed on September 7 last with the 35th launch. Targets included QF-80s, QB-47s, and KD2U Regulus 2s flying at 800kt; last March an IM-99B passed within lethal radius of a Regulus flying at 55,000ft and was finally homed on to a simulated target 446 miles out at an altitude of 100,000ft (no real target drone could have got there). Phase 2 trials have been in hand by Air Force crews since January 23.

Deliveries to Air Defense Command are now in full swing. Kincheloe AFB, Sault St Marie, Michigan, and Duluth Municipal Airport, Minnesota, are both operational, and Niagara Falls Municipal Airport, New York, is a few days from readiness; still being built are McGuire, Langley and Otis AFBs (all existing Bomarc A bases), and two Canadian bases, North Bay, Ontario, and La Macaza, Quebec. The RCAF chose Bomarc to replace the home-grown Arrow intercepter, and Canadair make Bomarc wings and ailerons for Boeing.

CONTRAVES/OERLIKON

DETAILS of the liquid-propellant missile, and attendant ground equipment, developed as a company venture in Switzerland and Italy were given in our 1958 and 1959 reviews, and brief details of the Contraves RSD appear in Table 4. The company are still unable to release any details on their entirely new weapon system with a solid-propellant motor.

HAWK

Radar-homing missile for mobile, low-altitude defence

US ARMY (*Surface/Air Missile A-18, M3EI*), US MARINE CORPS AND ARMIES OF BELGIUM, FEDERAL GERMANY, FRANCE, ITALY, THE NETHERLANDS AND SWEDEN

PRIME contractor for the Homing All-the-Way Killer is Raytheon, of Lexington, Massachusetts, who are responsible for the complete guidance system. This system is one of the first to be developed capable of employment against low-flying aircraft, and it comprises a continuous-wave radar of the Doppler type which can discriminate between the target and the background "clutter." The missile itself is based upon an Aerojet-General solid motor with high-specific-impulse boost and sustainer charges contained within a deep-drawn case. To the latter are attached the warhead bay, guidance receiver and radome, and the Norair-built cruciform of wings with trailing-edge elevons.

Although it can be emplaced for the defence of fixed sites, Hawk's prime role is the pro-

tection of combat troops. To this end, the entire weapon system is transportable by assault aircraft and helicopters, and is fully mobile across unprepared surfaces. The triple launcher can maintain a high rate of fire, loaded by the special tracked vehicle illustrated on page 693. The US Army has activated 13 battalions, which are being deployed in Germany, Okinawa and Panama Canal Zone. Each battalion has a peacetime strength of about 100, with from six to 12 triple launchers.

In 1958 five NATO nations announced their adoption of Hawk, and under the management of the SETEL Company the following chief contractors are building the complete weapon system: CF Thomson-Houston, France; Finmeccanica, Italy; Telefunken, West Germany; Ateliers de Construction Electrique de Charleroi, Belgium; and Philips, Netherlands. Last year Sweden also chose this missile, purchasing the equipment from the US Army.

Hawk battalions have been operational since early last year. Among the missile's achievements are the destruction of several other missiles, including Honest John, Little John and Corporal.

MASURCA

Radar-command missile for surface ships

FRENCH NAVY

SOLE survivor of the once numerous family of French anti-aircraft missiles, Masurca (*marine surface contre avions*) is a fully developed weapon system managed by the Ruelle naval arsenal. The missile is fired from beneath a rail launcher under the thrust of a tandem booster with 1,100lb propellant. Sustainer propulsion is provided by an end-burning 882lb charge which is fed towards the nozzle by hydraulic pressure. The missile is gathered in a pencil beam, which is then progressively made coincident with the radar beam to the target, the warhead being detonated by ground command when the ranges of target and missile are the same. System tests from the *Ile d'Oléron* have been satisfactory, and the weapon is scheduled for new escorts, a carrier and a cruiser.

MAULER

Radar-homing missile for mobile deployment in forward areas

US ARMY

ALTHOUGH it represents no dramatic "breakthrough" in technology, this new weapon system is the first in the world designed to provide sure defence against not only low-flying, high-performance aircraft, but also against tactical guided missiles and free rockets. It is intended to be employed in amphibious or airborne assaults, and to provide immediate and continuous fire-power.

Prime contractor is General Dynamics/Pomona. Basis of the missile is a deep-drawn tube containing the two-stage plastisol motor charge, hot gas from which is bled to drive the actuators for the four control fins. Ahead of the motor is the warhead, and the radar guidance receiver is in the nose. Missiles are delivered in a rigid box of sandwich construction, which is mounted in groups of 12 on the XM546 tracked vehicle together with all other elements of the system. Outstanding among the latter are the Raytheon acquisition and tracking radars, which are stabilized to permit targets to be engaged while the vehicle is speeding across rough terrain. Each vehicle is entirely self-contained, with power supply, radars, Burroughs computer fire-control, missiles and crew of two, the combat weight of the system being 25,000lb.

NIKE AJAX

DESCRIPTIONS of this pioneer surface-to-air weapon will be found in earlier reviews, particularly that of 1956. The US Army are about 50 per cent converted to the far more effective Hercules, but Ajax missiles are deployed on over 1,500 launchers with many NATO nations, in Japan and elsewhere.

NIKE HERCULES

Radar-command missile for fixed/mobile deployment

US ARMY (*Surface/Air Missile A-25*), NATIONALIST CHINESE FORCES

REPLACING Nike Ajax on launchers in the USA, Germany, Okinawa, Alaska, Japan, and elsewhere, this missile has an extremely high flight performance which matches its very powerful radar guidance system. Prime contractor is Western Electric, assisted by Douglas Aircraft (airframe), Hercules Powder Co and Thiokol for propulsion and General Electric for guidance radar. Official figures for the number of launchers have not been given, but the figures of "approximately 80 batteries, each with nine launchers" given in our 1960 review is accurate. The new mobile launcher was first illustrated in *Flight* for October 12.

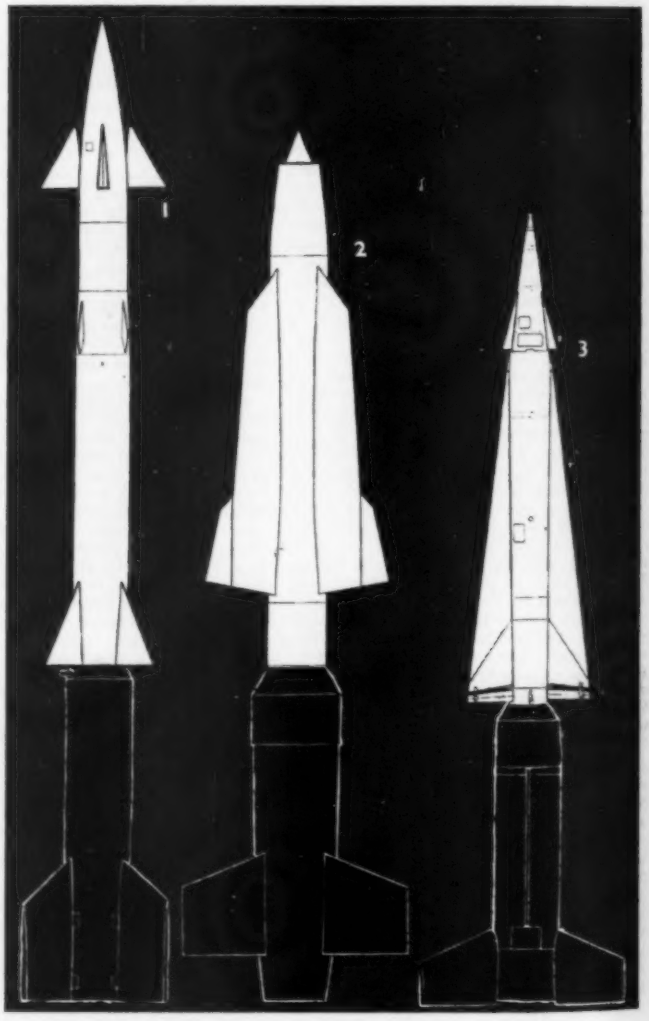
NIKE ZEUS

Radar-command anti-missile system

US ARMY

UNTIL very recently it seemed that no defence against an ICBM was technically feasible; and even today it is impossible without expenditure of the order of £1,500,000,000 to defend any area at all. The only weapon system capable of intercepting the incoming re-entry vehicle—and far enough out for the explosion and fall-out not to be injurious to those below—is Nike Zeus, the third generation of radar-command missiles produced by the great team led by Western Electric. Critics of Zeus have pointed out that its roots go too far back in the past; neater and cleverer ideas are now in prospect, they say, and the vast expenditure which would be needed to deploy Zeus operationally is not justified. Such a viewpoint would probably be valid were it not for the importance of time; no later system could reach so advanced a degree of development for at least five years.

SURFACE-TO-AIR MISSILES: 1, Nike Zeus; 2, Typhon (long-range); 3, Nike Hercules. Jettisonable boost motors are drawn in solid black



The Zeus missile itself has three stages of high-impulse solid propulsion, the third being a spherical charge provided not so much to increase velocity as to steer the warhead in vacuum conditions by means of asymmetric thrust. Control within the atmosphere is effected by the cruciform of nose fins. Principal ground elements of the system are the acquisition, discrimination (between re-entry vehicle and decoys) and target-tracking radars, the first of which has probably been the greatest single development in the whole programme. Under the basic direction of the Army Rocket and Guided Missile Agency (now Army Ballistic Missile Agency), Bell Telephone Laboratories have handled the basic design of the equipment so far, and it is known that the acquisition radar has a multi-megawatt transmitter and a 1,000-ton receiver aerial of Luneberg-lens type. Tests of the discrimination radar are about to be made with re-entry vehicles and decoys from Atlas ICBMs fired down both Atlantic and Pacific ranges; this variable-beam radar also has multi-megawatt power and can in some way tell the false from the true. The tracking of the final target is straightforward, and this work is integrated by computer with the missile-track equipment to drive the Zeus into co-incidence with its quarry.

More than $100m of the $1,100m so far voted for the programme has been spent on test facilities. Target-track radar at Ascension Island was used against ICBMs earlier this year, many Zeus test vehicles have been fired from White Sands, and full-range testing of complete Zeus missiles is now possible from Point Mugu, California. But the greatest test site of all is at Kwajalein Atoll, in the Pacific, which is now filled from end to end with a complete Zeus weapon system. Before next March the entire system will be subjected to live testing against Atlas ICBMs fired by SAC from Vandenberg AFB, California. Upon the result of these critical tests will rest the massive decision: to scrap the programme, or commit Zeus to production at a cost of some $8,000m. At present, no production has been funded, although testing will be continued for a further year by a $171,821,000 contract placed with Western Electric and ten other contractors on September 27.

REDEYE

IR-homing missile for infantry

US ARMY, US MARINE CORPS

MODERN techniques of microminiaturization are progressively reducing the volume and weight of missile payloads and guidance systems. Today the Redeye, which theoretically has high lethality against high-performance aircraft, can be carried by a single soldier "through underbrush and rugged terrain." Under the direction of the Army Ballistic Missile Agency, General Dynamics/Pomona have evolved an incredibly small device, which is held at the shoulder and aimed with an optical sight. The launcher is approximately 4ft long and 3in diameter, and weighs about 20lb, and its tube is sealed to serve as the shipping container for the missile. The latter is described as "a composite structure containing propellant, an electronic guidance system and a high-explosive warhead." Guidance is officially stated to be by infra-red means, and the participation of Philco suggests the incorporation of Sidewinder experience.

SEACAT

Radio- or radar-command missile for close-range defence

ROYAL NAVY, ROYAL AUSTRALIAN NAVY, ROYAL NEW ZEALAND NAVY, *and evaluation by Federal Germany and Sweden*

IN a nutshell, Short Brothers & Harland Ltd, the prime contractors, describe Seacat as "a small and highly manœuvrable weapon, designed for close defence against low-flying aircraft. It has the lowest minimum range of any surface-to-air missile at present available. It will be very effective in combating any hostile aircraft which may evade a naval unit's outer defensive fighters and long-range guided weapons. It has also a surface-to-surface capability."

As the scale drawings emphasize, the missile is much smaller than most surface-to-air weapons, which facilitates stowage and handling, particularly aboard small ships. Propulsion is provided by a dual-thrust motor, immediately ahead of which are the autopilot unit and the actuator assembly for the four swept moving wings. Further ahead again the body swells to an almost square cross-section past the potted electronics pack, and the large warhead occupies the nose. Missiles are delivered and stored inside a rigid glass-fibre canister in a tubular frame. This frame serves as the transport pallet and can be hoisted and stacked, and a folding version is used for ship-to-ship transfer.

Ground equipment required for this weapon system is relatively simple, and can readily be incorporated in ships of down to some 500 tons displacement. The Mk 20 launcher carries four Seacats disposed around the

MORE SURFACE-TO-AIR MISSILES: 4, Nike Ajax; 5, Russian missile; 6, Talos (conventional warhead); 7, Masurca; 8, Terrier; 9, Russian missile; 10, Bloodhound 1; 11, Thunderbird 1; 12, Seaslug 1; 13, Tartar; 14, Seacat 1; 15, Seacat 2; 16, Mauler (provisional); 17, Bomarc B; 18, Hawk; 19, Redeye (drawn to twice the scale of the other missiles). Jettisonable boosters are again drawn in solid black

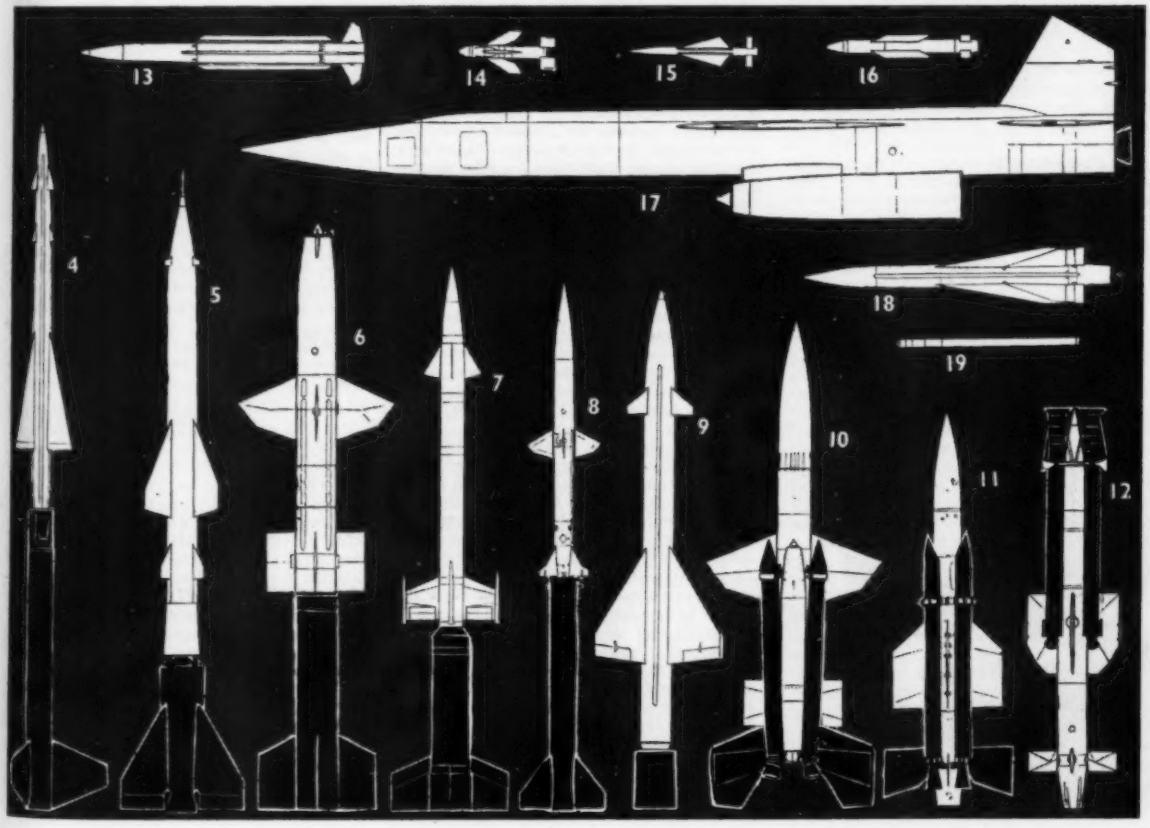


TABLE 4: SURFACE-TO-AIR MISSILES

	Range (n.m.)	Altitude limits (ft)	Launch weight (lb)		Length (ft)		Body diam (in)	Span (in)	Mach no
			+ boosts	without	+ boosts	without			
Bloodhound I	60+	—	—	—	25.25	22.2	21.5	112.5	—
IM-99A Bomarc ...	200	/68,000+	15,000	n.a.	47	n.a.	34.6	218	2.5
IM-99B Bomarc ...	440	0/100,000	16,000	n.a.	45	n.a.	34.6	218	3
Contraves RSD ...	18	—	n.a.	882	n.a.	19.75	15.75	53	2.4
Hawk	19.5	10/38,000	n.a.	1,275	n.a.	16.8	14	48	2+
Masurca	13.5	/70,000	3,198	1,653	28.2	19.1	—	55.1	2.5
Nike Ajax	26	5,00/60,000	2,300	1,100	34.9	21	12	53	2.5
Nike Hercules ...	74+	/150,000+	10,000	5,100	39.7	26.8	31.5	90	3.35
Nike Zeus	200+	/500,000	40,000?	—	63	42	60	98	11
Redeye	3?	10/5,000?	n.a.	20	n.a.	4	3	n.a.	2+
Seacat 1	—	0/10,000?	n.a.	—	n.a.	4.82	7.5	25.6	0.8?
Seacat 2	—	0/20,000	n.a.	—	n.a.	6.6?	7.5?	20?	1+
Seaslug 1	—	—	—	—	19.7	19.7	16.1	56.6	—
Talos	65+	90,000+	7,000	3,100	30.5	20.5	30	112	2.5
Tartar	9+	1,000/40,000	n.a.	1,500	n.a.	15	13	20	2.5+
Terrier	10.5	5,000/60,000	2,900	1,100	26.6	14.8	13	46	2.5
Terrier (Advanced) ...	20+	2,000/90,000	5,000	1,500	29.5	14.8	13	20	3
Thunderbird	20+	—	—	—	21	21	21	63	—
Typhon	200	0/120,000	20,000?	—	46	28	38	160	5

guidance aerial. The four rounds can be loaded in less than three minutes, and are each protected by hermetically sealed sheaths of plastics material through which the missile may be launched. The simplest guidance system (Blue Tallies) is by the Mk 20 director, manned by a control officer and aimer. The latter tracks the target through binoculars, and movements of the latter are transmitted electrically to the launcher control console, corrected, and then used to position the launcher in bearing and elevation. This ensures that when a missile is fired it comes into the aimer's field of view, and the aimer then drives it into coincidence with the target by radio command from a miniature control column.

Although no details have been divulged regarding the type of shipboard direction equipment which the Royal Navy will use with this missile, it seems likely that in all the smaller ships it will be this Blue Tallies system. The complete weapon system has been at sea for many months, and photographs have been released showing firing trials taking place at both high and low angles of elevation from HMS *Decoy* (a *Daring*-class destroyer).

If necessary, the missile can be integrated with various blind-fire radar directors (a model has been exhibited of Seacat with radar guidance by NV Hollandse Signaalapparaten). With alternative warheads and fuzes it can be employed against surface targets, and the land-based Tigercat (*q.v.*) is being developed as a private venture.

SEACAT 2

At the Paris Salon earlier this year Short Brothers exhibited models of this second-generation weapon, which they are at present developing as a private venture. It is described as supersonic and "of higher potential," although it should be possible for the Seacat 2 system to employ much of the equipment developed for Seacat 1. The data given in Table 4 are estimated, but the changed appearance of the new missile is evident from the drawing. Body cross-section remains circular throughout, and the missile has entirely new fixed wings and rear control fins.

Redeye can be fired from the shoulder, even from foxholes or ravines

SEASLUG

Beam-riding missile for surface ships

ROYAL NAVY

FIRST of Britain's guided-weapon programmes, this ship-to-air weapon system for the Royal Navy has in 12 years been brought to an excellent state of development; and there is no doubt that today it far surpasses the original design specification, and is as effective in its role as any missile in the world. Development has been handled for the Admiralty by three main contractors, Whitworth Gloster Aircraft (formerly Armstrong Whitworth, whose name is still borne by the missile), GEC and Sperry Gyroscope Co. They have been respectively responsible for the airframe, guidance and control system.

In order to minimize the space required for storage, Seaslug's four boost motors are mounted around the forebody, where they need no stabilizing fins. From the ship's magazine missiles are automatically fed through checkout rooms and up to the multiple launcher on the quarter-deck. After targets have been picked up by the air-warning radar, they are passed to a long-range direction radar which controls the missile guidance radar and puts the latter's pencil beam on target. When a missile is launched the following sequence occurs: boost motors fire; boosts separate and solid sustainer fires; missile is roll-stabilized with the correct fin vertical; missile is gathered into centre of guidance beam, with full control response; flight up the centre of the conical-scan guidance beam, with reduced control response owing to the increased signal strength; detonation of the warhead by the proximity fuze.

The complete and largely automatic shipboard control and guidance systems, and their associated test equipment, have been developed with the trials ship HMS *Girdle Ness*. Between July 1959 and April 1961 this ship thoroughly tested every aspect of Seaslug operations during live firings in the Mediterranean against various target aircraft, and she returned in July to complete the trials and allow the missile to be cleared for service. In its final firings Seaslug demonstrated its ability to destroy eight out of every ten aircraft engaged at heights from well over 50,000ft down to very low levels. In one series of seven firings four targets were demolished by impact, and to conserve targets subsequent trials had to be programmed to miss by a predetermined distance. Last month three more Seaslugs were fired before NATO observers; two aircraft (one at high altitude and the other distant on the horizon) were destroyed by impact, and the third would have been destroyed had a warhead been fitted.

Twin launchers for Seaslug 1 are fitted to four *ad hoc* 5,000-ton ships of the Royal Navy, which are due to join the fleet between next summer and late 1963. On September 29 contracts were placed for two additional 5,200-ton ships, which will from the outset be designed for armament with Seaslug 2. First mentioned in the 1961 Navy Estimates, Seaslug 2 "will have greater range and speed . . . to deal with the types of aircraft likely to be encountered during the latter part of this decade"; its guidance receiver will be developed by GEC. Seaslug 2 will be retrospectively installed in the four earlier ships. The Federal German Republic has requested permission to build ships larger than 3,000-tons, and is closely watching Seaslug performance.

SOVIET MISSILES

IN the accompanying drawings, sketch 5 represents a missile seen in many public parades since 1957. Almost certainly a beam-rider, it has a tandem boost motor and rear controls; a photograph on page 693 shows that it can be launched at a remarkably low elevation. Sketch 9 depicts a missile first seen one year ago. Although of similar size to the earlier type, it appears to have a much smaller boost charge, and an entirely different configuration, with a cruciform of canard control surfaces. These weapons should be able to engage all targets up to heights of about 75,000ft, but far later concepts are implicit in the statement on October 23 by Marshal Malinovsky, Soviet Defence Minister, that "the problem of destroying rockets in flight has been successfully solved."

TALOS

Long-range missile for surface ships

US NAVY (*Surface/Air Missile N-6*)

ONE of the most expensive and complex of all weapon systems, Talos provides protection within a radius of some 70 miles but can be installed only in ships of at least 10,000 tons. The vehicle portion of the system is built around a 30in-diam ramjet duct, built by McDonnell for the prime contractor Bendix. After launch by a tandem boost motor, the ramjet lights up its mixture of kerosine and naphtha fed by turbopump from an annular tank. Nuclear-warhead Talos missiles are simple beam riders; those with conventional heads may be distinguished by projecting aerials and pitot tubes surrounding the air intake, and these have an additional semi-active terminal homing radar system. Talos, which was described at greater length in pre-1960 reviews, has been operational with the cruiser *Galveston* since 1959, and is being deployed aboard six more large ships including the nuclear-powered *Long Beach*. It has paved the way for Typhon (*q.v.*).

TARTAR

Radar-homing missile system for surface ships

US NAVY (*designation given as "Mark 15"*)

COMPACT enough to be deployed aboard destroyers, Tartar forms the primary anti-aircraft armament of such ships, and is also being introduced as secondary armament on certain cruisers. The missile was developed by General Dynamics/Pomona and the Bureau of Naval Weapons, under the technical direction of Johns Hopkins University. Superficially similar to Terrier (advanced), Tartar differs in having homing guidance and no jettisonable booster—and also in many other respects which are not externally evident. When Tartar is fed to the launcher the tail controls unfold automatically. Propulsion is provided by a boost/sustainer motor of advanced design by Aerojet-General, hot gas from which drives the a.p.u. providing electrical and hydraulic power. The missile is guided by Raytheon's new SPG-51 radar, which is mounted on the unique gearless Mk 73 director by General Electric. The airborne homing and control systems are packaged into interrelated units "so constructed that they form the basic airframe." Tartar can be used against aircraft at high and low levels, and will serve aboard three cruisers and 23 destroyers, eight of the latter already being in commission.

TERRIER

Beam-riding missile for surface ships or mobile land forces.

US NAVY (*Surface/Air Missile N-7*), US MARINE CORPS, ITALIAN NAVY

FOLLOWING seven years of research by Johns Hopkins University, General Dynamics/Pomona (then Convair) and their subcontractors began to deliver Terrier 1 in 1956, at which time it was the only ship-to-air missile in operational service in the world. The same missile is employed from mobile land-based launchers by two medium anti-aircraft battalions of the USMC. A complete set of system components has been supplied for the Italian cruiser *Garibaldi*. This weapon system was described fully in the 1956 review.

TERRIER (ADVANCED)

Beam-riding missile for surface ships or mobile land forces

US NAVY, US MARINE CORPS

KNOWN variously as Terrier 2, Advanced Terrier and Terric. (advanced), this weapon will probably soon be known simply by the one word Terrier, for it is destined to replace the earlier version entirely. It has the slender wings and rear controls of Tartar, whereas the original Terrier had fixed rear fins and a cruciform of moving wings (sketch 8). Unlike Tartar, Terrier (advanced) has no homing system, although the guidance radar and the airborne guidance and control systems are very considerably improved. The contrast in range between the two Terrier versions is obvious from Table 4. Terrier (advanced) entered service early last year aboard the frigate *Dewey;* at the time of writing, 16 ships are operational, and the eventual total will comprise 23 frigates, four cruisers and two carriers. The missile is also being delivered to land-based Marine Corps units.

THUNDERBIRD

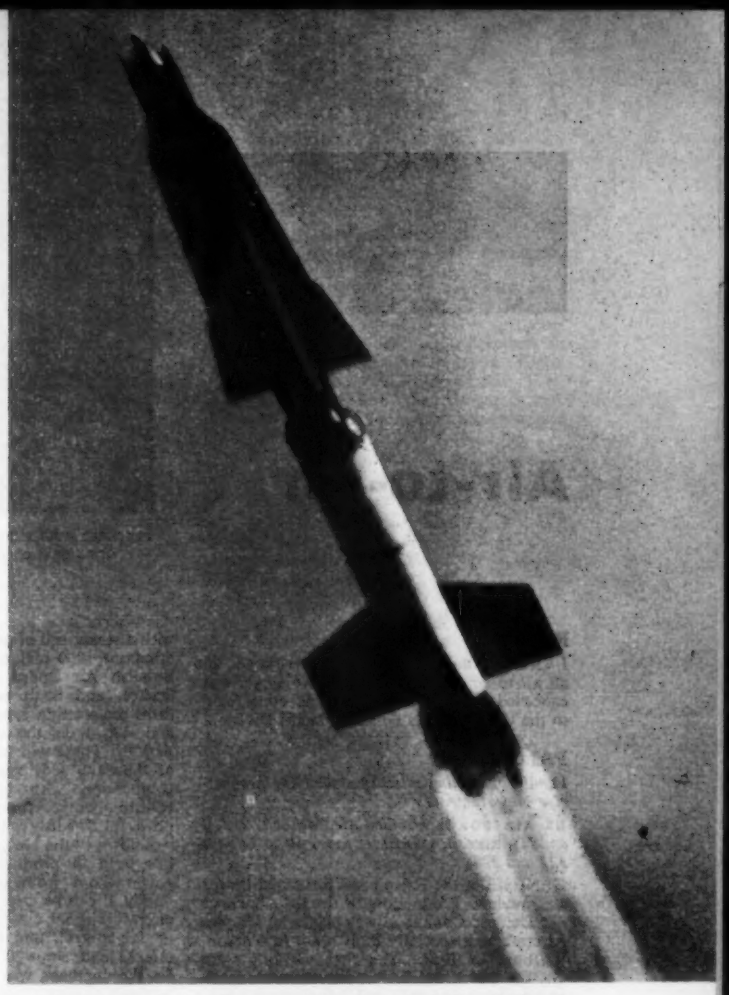
Semi-active radar-homing missile for mobile deployment

BRITISH ARMY

DEVELOPED by English Electric Aviation since 1950, Thunderbird 1 has been in full service with regiments of the Royal Artillery for more than two-and-a-half years. From the outset the complete weapon system has been designed to provide protection against aircraft capable of operating at extreme speeds and altitudes, to be completely mobile and capable of rapid deployment to a new theatre, to have very brief reaction time and to be capable of repair by immediate replacement of any malfunctioning unit.

Thunderbird is launched by four wrap-round boost motors, and incorporates a solid sustainer motor. The missile is controlled by the four rear fins (which in sketch 11 are hidden by the large fins on the boost motors), and made to follow a proportional-navigational course according to signals from the guidance receiver behind the nose radome. A proximity fuze detonates the large conventional warhead; it has been said that later Thunderbirds will have a nuclear warhead. Last month one Thunderbird regiment was sent to bolster the British Army of the Rhine, and additional units are in the process of formation. The Army's practice range is at Ty Croes, Anglesey, and the training school is at Manorbier, Pembrokeshire.

Now in an advanced stage of development is Thunderbird 2. Like Bloodhound 2, the new missile incorporates CW guidance, giving greatly improved resistance to countermeasures and better discrimination against low-altitude targets. Radar power has also been substantially increased, to match the much higher flight performance of the new weapon. Total weapon-system weight has been cut to a minimum, and many portions are mounted on light pallets or trailers in order to make the whole system air-portable in the Argosy. English Electric Aviation list further improvements as: automatic operation; self-contained, and capable of independent operation; faster into action; reduced number of personnel and vehicles; and simplified field storage, maintenance and repair.



Launch of the first Typhon (long-range) development vehicle, which took place recently at White Sands Missile Range

TYPHON

Radar-homing missile for surface ships

US NAVY

DURING the past 12 years the original "Bumblebee" programme of the Johns Hopkins University has produced the Terrier, Tartar and Talos family of anti-aircraft weapons. Logical development at the University's Applied Physics Laboratory led to projects originally styled Super Tartar and Super Talos, but now known as medium-range Typhon and longe-range Typhon. The latter was put on a firm basis in June of this year, with the award of the prime contract to Bendix and the airframe to McDonnell, under the technical direction of JHU. This team, which have worked together for ten years on Talos, are producing a jagged-looking missile reminiscent of the earlier Zeus test vehicles: the wings have extremely low aspect ratio, and carry delta control surfaces at their rear tips. Westinghouse have the contract to produce a new type of random-pulse radar, which will eliminate 13 current types of radar and permit ten simultaneous firings at ten targets. An unofficial report states that the missile's own active-homing radar will be powerful enough to penetrate intense countermeasures and jamming. The enormously improved performance of long-range Typhon is evident from Table 4; it is also to set new standards in quick reaction time, target-handling capacity and guidance accuracy. The missile is to become operational in 1966.

Air-to-Air

Excellent results are being achieved by the Société Matra with the R.530; it is to be standard armament on the Mirage 3C, an example of which is carrying it in this photograph

EAGLE

LARGEST and by far the longest-ranged of all air-to-air weapons, the 2,000lb Eagle was cancelled early this year. Prime contractor to the US Navy was Bendix Systems Division.

FALCON

Family of homing missiles embodying progressive improvements

US AIR FORCE (*Guided Air Rocket 1, 2, 3, 4 and 11*), ROYAL SWEDISH AIR FORCE (*Robot 327 and 328*)

GENESIS of the Falcon was described in our 1957 review. Production for the US Air Force Air Defense Command was begun by Hughes Aircraft at a specially built plant in Tucson, Arizona, in 1954. The first versions were GAR-1 and GAR-2, respectively with semi-active radar and infra-red homing guidance. After delivering some 4,000 GAR-1s, Hughes switched to the GAR-1D, with larger control surfaces carried well behind the wing, and delivered nearly 12,000 between 1956 and 1959. Production of IR-homing missiles began in 1956, and from 1957 the GAR-2A allowed for operation over a wider band of ambient temperatures, total -2 and -2A production amounting to 9,500. These missiles are still found in units equipped with the F-101B and F-102A, and some may be supplied to the RCAF for use on the former aircraft.

First of the Super Falcons was the GAR-3, introduced in 1958 for issue to F-106 squadrons. Completely redesigned, it has much improved radar guidance, a pointed radome of new material, a more powerful warhead, new wings and a longer-burning motor. After delivering 300, Hughes moved on to the GAR-3A, with better guidance discrimination and a completely new motor. Deliveries probably now exceed 2,000. In parallel, Hughes are making the IR-homing GAR-4A, with a seeker cell of greater sensitivity. Shortly after our 1960 review was written the Royal Swedish Air Board obtained a production licence, and Saab assisted by many other firms are starting production of the GAR-3A and -4A, under the designations Rb327 and Rb328. These will form the main armament of the Saab J35F version of the Draken, in conjunction with an improved Saab S7 collision-course fire-control and a more powerful Swedish radar.

Known as the Nuclear Falcon, the GAR-11 has been in production about 18 months. An offshoot from earlier members of the family, it can be fitted to the F-102 and other aircraft without modification to the launcher or fire-control, and has radar guidance for attacks made some 20° to 30° from dead ahead. Its development was a triumph of kiloton-warhead design.

FIRESTREAK

IR-homing missile

ROYAL AIR FORCE, ROYAL NAVY

ORIGINALLY known by the code name Blue Jay, this weapon has been developed by de Havilland (originally the Propeller Co, now de Havilland Aircraft, Manor Road, Hatfield) since 1951. As described in *Flight* for February 26, 1960, the missile is guided by an infra-red seeker cell behind the glass nose, which locks-on to the target before release from the launch aircraft. Signals of telescope dish position are processed by potted electronics in the forebody and used to control pneumatic actuators ahead of the wings coupled by rods to the rear control surfaces. Proximity-fuze windows in the forebody trigger the warhead surrounding the motor tube. Firestreaks are the primary weapons of squadrons equipped with the Lightning (two missiles per aircraft), Sea Vixen and Javelin (four).

GENIE

Unguided nuclear rocket

US AIR FORCE

AS intimated in our 1960 review, this fin-stabilized missile is likely to be carried by later types of Lightning of RAF Fighter Command, as well as the F-101Bs of the RCAF. It is widely used by F-101B, F-102 and F-106 squadrons of Air Defense Command, and is said to have a warhead with a lethal radius of more than 1,000ft.

MATRA R.511

Semi-active radar homing missile

FRENCH AIR FORCE

DESCRIBED in *Flight* for August 19, 1960, this twist-and-steer missile was originally developed with an *autodirecteur* containing a light-sensitive optical seeker cell. This was abandoned in favour of radar, but overall performance limitations have restricted the R.511's employment to training and indoctrination, almost entirely with Vautour squadrons.

MATRA R.530

Radar or IR homing missile

FRENCH AIR FORCE

EARLIER Matra and Nord air-to-air missiles have been interim designs, developed to fill the gap until this definitive weapon is ready. Abandoning twist-and-steer in favour of cruciform surfaces, Matra have produced a finely engineered missile of high performance. Behind the hemispherical nose lies the stabilized IR telescope or semi-active radar dish aerial, both versions being described as "of equal importance." Next comes the continuous-rod warhead, with four axial proximity-fuze aerials, followed by the autopilot, electric batteries, upper and lower cable

TABLE 5: AIR-TO-AIR MISSILES

	Launch wt (lb)	Length (in)	Body diam (in)	Span (in)	Range (n.m.)	Altitude peak (ft)	Mach number	Warhead
GAR-1D Falcon	121	78	6.4	20	4.5	50,000	2+	20lb?
GAR-2A Falcon...	120.5	79.5	6.4	20	4.5+	50,000	2+	20lb?
GAR-3A Falcon...	150	86	6.6	24	6+	70,000	3	40lb?
GAR-4A Falcon...	145	81	6.6	24	6+	75,000	3	40lb?
GAR-11 Nuclear Falcon	203	84	11	20	4?	—	2	N (2kT?)
Firestreak	300	125	8.67	29.4	4+	—	2+	50lb?
MB-1 Genie	820	114.9	17.4	—	2.5	50,000+	3	N (2kT?)
Matra R.511	397	122	10.24	39.4	4.1	59,000	1.8	55lb
Matra R.530	430	133	10.24	43.3	—	98,500	2+	60lb?
Nord AA.20 (5103)	295	102.4	9.84	31.5	2.5	50,000	1.7	51lb
Nord AA.25 (5104)	298	102.4	9.84	31.5	3	—	1.7	51lb
Red Top	—	—	—	—	7	—	3+	68lb
Sidewinder IA	155	113	4.8	20	2+*	50,000+	2.5	10lb
Sispre C-7	143	77	6.3	25	6.2	—	1.9	55lb
Sparrow 3	380	144	8.5	39	5+	50,000+	2.3+	60lb

* Reduced to about 3,500ft at sea level.

fairings and two-stage motor. One pair of wings have ailerons, to limit rate of roll, and the control surfaces are at the rear. Trials from Canberras and Vautours at Colomb-Béchar are encouraging, and weapon-system firings are in hand from Mirages at Cazaux. The R.530 is to be the primary armament of the Mirage III. Matra are looking at the NATO military committee requirement for a standard air-to-air missile, and are collaborating with de Havilland in this field.

NORD 5103 (AA.20)

Radio-command missile

FRENCH AIR FORCE, FRENCH NAVY (*Air/Air Missile 20, Type M2RT*)

BY setting their sights at a not too ambitious concept, Nord-Aviation achieved operational capability with this weapon in 1956. As was remarked in our full description of it on July 15, 1960, "Although the AA.20 was from the outset intended to be a fully effective operational weapon, it was generally regarded as an interim missile pending development of the R.530 series . . ." Accordingly, it is steered by command signals in a coded radio link, governed by a miniature joystick manipulated by the pilot of the launching aircraft. This means that the target and missile flare must be visible to the pilot right up to the point (50ft distance) at which the proximity fuze is triggered. Steering is effected by pitch and yaw demands which bias the interruption of vibrating spoilers in the two nozzles from the sustainer. AA.20 is in use from ten types of French aircraft, and has given rise to later air-to-air and air-to-surface missiles.

NORD 5104 (AA.25)

Radar-command missile

FRENCH AIR FORCE (*Air/Air Missile 25*)

ADOPTION of radar command guidance makes it no longer necessary for the pilot of the launching aircraft to see the target or steer the missile. This weapon is compatible with the Cyrano radar of the Mirage III, and has also been integrated with US and British radars.

RED TOP

IR-homing missile

ROYAL AIR FORCE, ROYAL NAVY

REVEALED since our 1960 review, this weapon has a performance and lethality very much greater even than that of Firestreak, which it is destined to replace and from which it has been evolved. The prime contractors, de Havilland Aircraft (formerly de Havilland Propellers), have stressed how difficult it is to achieve a hit "under the most adverse conditions," and state that new techniques give Red Top "greatly enhanced capabilities." Compared with Firestreak, the main components are rearranged: the warhead has gone to the obvious place—up front, next to the fuzing system—and the control actuators are moved aft, next to the surfaces they drive. Full body diameter is maintained from front to rear, making room for a larger warhead and motor; and performance at great heights is improved by the new wings and control fins. The Red Top display model has an IR head covered by an octagonal glass nose, like Firestreak. While development is hustled to meet the requirements of late-model Lightnings and other aircraft, D.H. are collaborating with the French Société Matra on radar guidance and other aspects of similar weapons.

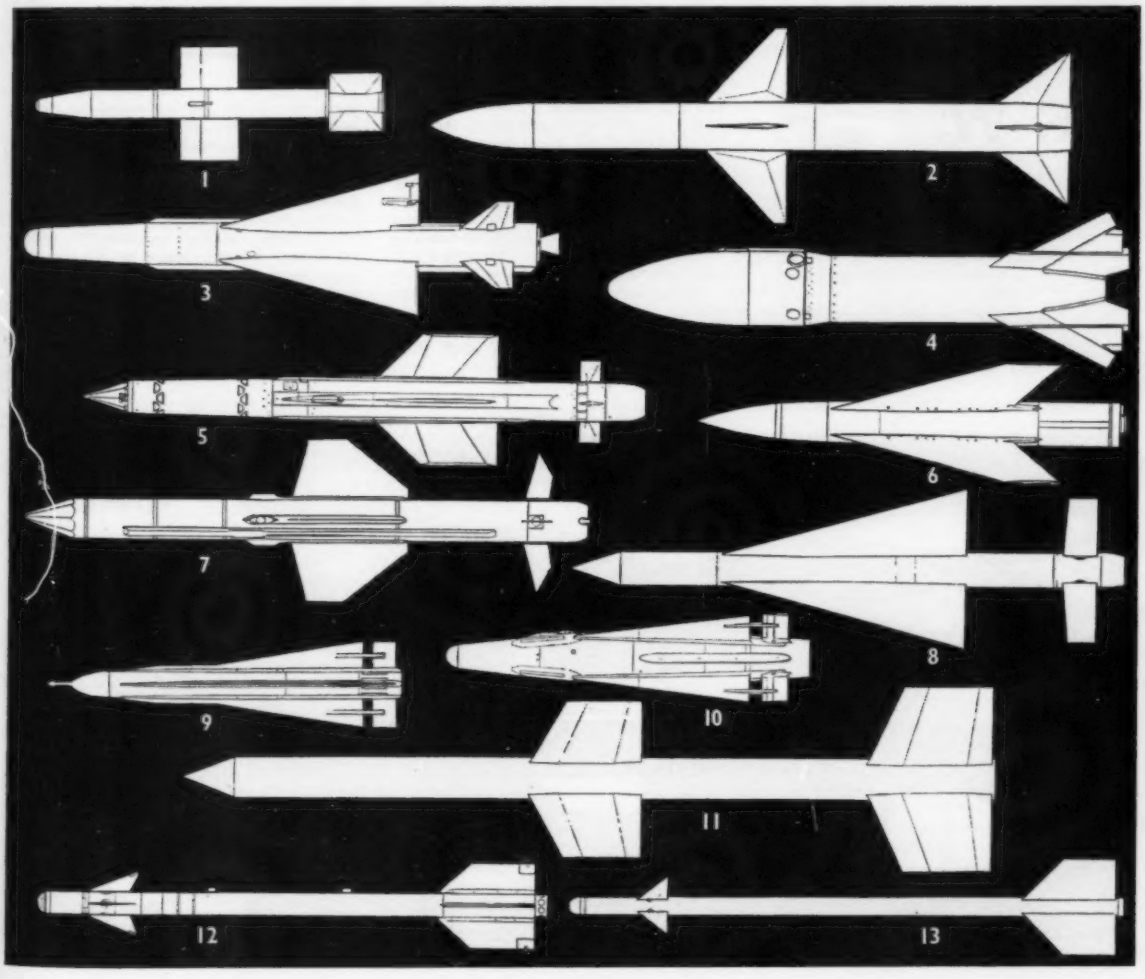
SIDEWINDER

IR, or IR and radar, homing missile

US NAVY (*Air/Air Missile N-7*), US AIR FORCE (*Guided Air Rocket 8*), US MARINE CORPS, ROYAL NAVY, ROYAL CANADIAN NAVY, *and air forces of 12 nations including Australia, Japan, Nationalist China and Sweden*

NO better tribute can be paid to a product than a long list of presumably satisfied customers, and Sidewinders have been bought by (and given to) more nations than any other missile. Developed at the Naval Ordnance Test Station at China Lake, California (see 1957 review), the original N-7, or SW-1A,

AIR-TO-AIR MISSILES: 1, Sispre C-7; 2, Sparrow 3; 3, Matra R.530; 4, Genie; 5, Firestreak; 6, Nord AA.20; 7, Red Top; 8, Russian missile carried by Blinder; 9, GAR-4A Falcon; 10, GAR-11, Nuclear Falcon; 11, Russian missile carried by large (Mikoyan?) delta; 12, SW-1A Sidewinder; 13, Russian missile for all day fighters



consists of a light-alloy tube containing the IR-seeking head, front controls, distributed warheads, motor, and rear fins carrying slip-stream-driven gyros. Some 50,000 have been delivered by Philco and the second-source contractor General Electric. Some were fired very effectively against Chinese aircraft by Chiang Kai-Shek's forces during the Quemoy crisis of 1958. Now nearing release to service is the SW-1C model, in which either an IR or a semi-active radar homing head may be fitted. Either can be attached, according to the conditions prevailing. The SW-1C also has greater body volume, increased flight performance and a larger warhead, but it demands a radar-equipped carrier aircraft.

SISPRE C-7

IR-homing missile

ITALIAN AIR FORCE

PRODUCED by Societa Italiana Sviluppo Propulsione a Reazione, a subsidiary of Fiat and Finmeccanica, this simple and cheap weapon is about to enter service with units equipped with the Fiat G.91 and F-86. Like Bloodhound, it manœuvres by twist-and-steer from a single pair of wings; other features include a wide-angle heat-seeker behind the hemispherical glass nose, and extreme system simplicity.

SOVIET MISSILES

UNTIL July 9, 1961, no Soviet air-launched missile had been seen publicly. On that date eight types of missile, all of quite individual and distinctive design, were carried by the aircraft taking part in the Tushino display. Of these eight, three are almost certainly air-to-air missiles, and these are included in the drawings for this section. One is so like the American Sidewinder as to make the thought "copy" come to mind. A giant weapon has a body of high fineness ratio and large, squarish wings and fins, and is carried by an aircraft (E-166?) of extremely high performance. The third model has very large delta wings and Seaslug-like tail controls, and seems to resemble a much-enlarged Falcon: this missile must weigh 600lb, and is carried by a large twin-engined machine said to be the Yak-42. For the rest, we will leave readers to make deductions from the drawings.

SPARROW

Radar-homing missile

US NAVY, US MARINE CORPS (*Air / Air Missile N-8*)

CLAIMED to be "the world's best performing operational air-to-air missile," Sparrow 3 has completely replaced the obsolete Sparrow 1 (Sparrow 2 being stillborn). Raytheon developed Sparrow 3 at Bedford, Massachusetts, and make it in the Navy-owned plant at Bristol, Tennessee, and at the Aero/Weapons division in Lowell, Mass. Final checkout and flight-test is done at Oxnard and Pt Mugu, California. Powered by a Thiokol pre-packaged liquid motor, Sparrow 3 has semi-active homing radar guidance, manœuvres by cruciforms of wings and rear controls, can be fired singly or in sequence against an unseen target from various launch-aircraft attitudes, and has a warhead "with at least 50 per cent more explosive than previous US air-to-air guided missiles." Operational since 1958 with Pacific and Atlantic Fleets, Sparrow 3 is now being supplemented by the advanced 3B version, tailored to the needs of the McDonnell F4H Phantom 2.

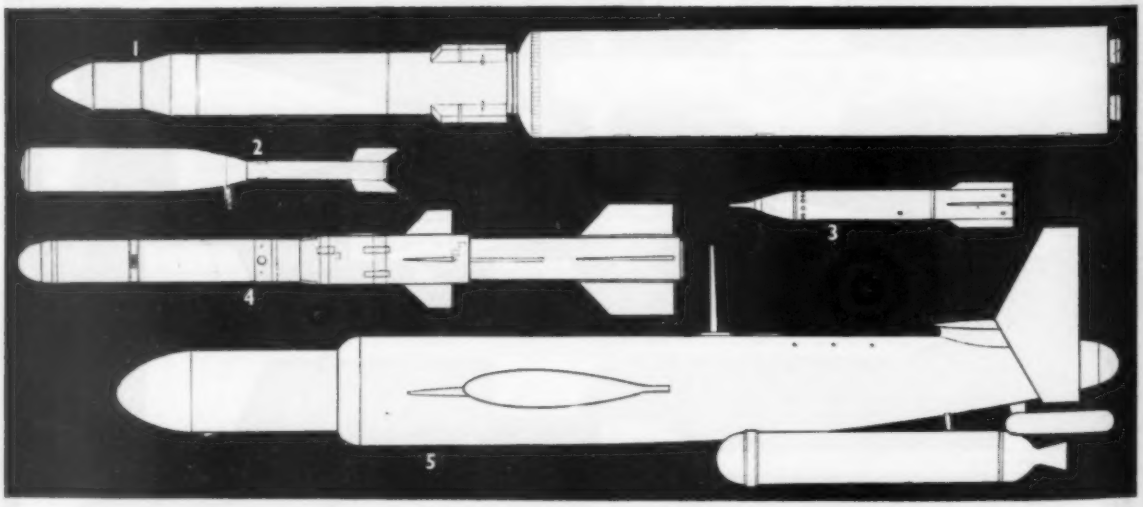
TABLE 6: A S W MISSILES

	Mission	Propulsion sequence	Range (yd)	Launch wt (lb)	Length (in)	Body diam (in)	Warhead
Alfa	S-A-U	Internal rocket	900	500	102	12.75	h.e.
Asroc	S-A-U	Rocket, then torpedo	16,000	2,500	180	30	500lb
Astor	U-A-U	Rocket-boosted torpedo	2,000	2,300?	220	21	N (10kT?)
Malafon	S-A-U	Rocket, glider, torpedo	19,000	2,900	236	25	221lb
Subroc	U-A-U	Rocket, then ballistic	80,000?	7,000?	260	30	N (20kT?)
Terne 3	S-A-U	Internal rocket	5,500	265	77.5	7.9	106lb

A S W

ANTI-SUBMARINE WARFARE was first brought into a *Flight* review of the world's missiles in 1960. This year there is little to add to what was then published, although a vast amount of research has been conducted in order to enable such advanced weapons as Subroc to become operational. **Alfa** has long been a standard weapon, and is basically a rocket-propelled depth charge without air-borne guidance. **Asroc** is an electrically propelled, acoustic-homing torpedo, launched by an 11,000lb-thrust boost motor which is cut-off and jettisoned at a point suitable for the desired range; this Minneapolis-Honeywell weapon system entered service with the US Navy earlier this year aboard the large destroyers *Norfolk* and *Peary*, and is eventually to be installed in 150 ships. **Astor** is a submarine-launched torpedo system, unofficially said to incorporate wire guidance and rocket propulsion and to be operational aboard "killer" submarines. **Malafon**, a product of the French Soc Latécoère, is a small glider launched by two rocket boost motors from a ramp which can be controlled in bearing and elevation; the 50th Malafon 233 (Mq 2, Mod 1) was exhibited in Paris recently, and this operational version (sketch 5 below) differs from its predecessors in having two instead of three fins, and an improved acoustic-homing torpedo. **Subroc**, the most advanced of all ASW systems, has been brought by Goodyear Aircraft close to the point of operational service, and should start fleet trials with the nuclear-powered attack submarine *Thresher* early in the new year. The Norwegian **Terne** system—fully described last year—continues to be developed, and Terne 3 has undergone an evaluation by the US Navy.

ANTI-SUBMARINE MISSILES: 1, Subroc; 2, Alfa; 3, Terne; 4, Asroc; 5, Malafon Mq 2



Nord SS.11 fired from Bell HU-1A Iroquois during US Army trials at Aberdeen Proving Ground, Maryland

Anti-tank

All the weapons in this section are guided by operator command signals transmitted through wires paid out by the missile. Missiles are arbitrarily classed as light (up to 25lb firing weight), medium (up to 50lb) or heavy.

BANTAM

Light infantry weapon

PRIVATE VENTURE

DEVELOPMENT of this exceptionally light missile by A.B. Bofors was completed this year, and it is now fighting to achieve success in what is by far the most competitive guided-weapon field. Bantam can be combined in batteries on a vehicle, and an infantryman can carry a back-pack containing the missile (wings folded) and 33ft cable, the control unit being separate. The latter contains a system-test button, tracer selector (one or all four traces), missile selector (up to three can be connected at a time), safety firing button, monocular sight and joystick. The missile is fired from its case, as follows: battery activated; gyro pellet fired; booster ignited; gyro uncaged; missile leaves container (0.35sec); wings fully spread (0.45sec); sustainer and tracers ignite (1.1sec); fuze armed (2.5sec); impact up to 6,500ft (24 sec). The head is detonated by electrical contact between the two nose skins, even with glancing blows of 10° angle. Penetration exceeds 450mm (18in), and 500mm (20 in) is anticipated. During recent demonstrations for the Swedish Army and subsequently for 12 other nations, 17 hits were obtained with 20 rounds under very trying conditions. Bantams are "being supplied to various countries" for field trials, and bulk production will begin next summer.

COBRA

Light infantry weapon

FEDERAL GERMAN ARMY

IN an informative account of this weapon in our October 19 issue (page 617), the manufacturers, Bölkow-Entwicklungen, were quoted as saying that Cobra "is by far the lightest and cheapest weapon so far available, and is already in production." One unique feature is that its angled boost charge gives it a jump-start from bare ground to a height of 10ft; and during this leap the gyro is spun-up by a cord fixed at its other end to a stake in the ground. Two missiles, 65ft extension cables, junction box and firing box can be set up by one man in under 2min; up to eight can be coupled to one firing box, and batteries of six or ten can be vehicle-mounted. Most of the airframe is reinforced plastics, alternative warheads are connected only by a quick-thread, and the fuze is armed by boost acceleration. Up to 24in penetration is being obtained. Large orders are being fulfilled for

Launch of Malkara from air-portable Royal Armoured Corps vehicle

ANTI-TANK MISSILES: 1, Nord SS.10; 2, Nord SS.11; 3, Mosquito; 4, Entac; 5, Malkara; 6, Cobra; 7, Bantam; 8, Vigilant; 9, Python

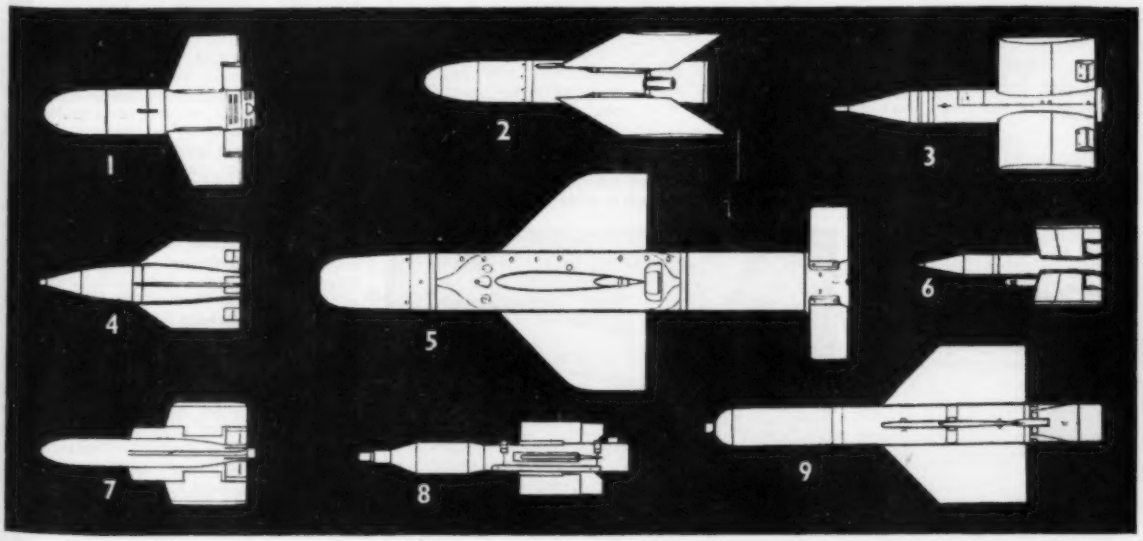


TABLE 7: ANTI-TANK MISSILES

	Launch wt (lb)	Warhead (lb)	Length (in)	Body diam (in)	Span (in)	Range limits (ft)	Speed (m.p.h.)
Bantam	13.2	3.1	33	4.3	15.8	1,000–6,500	191
Cobra	20.9	5.5	42	3.9	19	1,640–5,250	190
Entac	26.5	—	32.6	5.5	15	–5,800	190
Malkara	206	60	76	8	31	1,000–6,000+	400
Mosquito	26.5	7.3	44.1	4.7	23.6	1,200–6,600	211
Nord SS.10 ...	33	11	33.9	6.5	29.5	990–5,250	180
Nord SS.11 ...	64	17.5	45.9	6.5	19.7	1,650–11,500	425
Python	80	30	60	6	24	—	—
Vigilant	31	12	42	4.5	11	500–4,500	340

the German Army, 250 (evaluation) are on order for Holland, evaluations have been made by the US Marine Corps and 7th Army, and Daystrom Inc hold a production licence.

ENTAC

Medium infantry missile

FRENCH ARMY, US ARMY, BELGIAN ARMY

EIGHT months ago this missile achieved the order sought by five others—bulk inventory purchase by the US Army. Entac (*Engin Tactique Anti-Chars*) was developed by the Direction des Etudes et Fabrications d'Armément, in competition with the industry-developed Nord SS.10. Taking more than twice as long as Nord, the government personnel delayed finalization in order to achieve a better weapon. Entac is lighter than SS.10, flies faster, has greater range, and—above all—has a partly velocity-type control system, instead of the difficult acceleration control. Originally Entac needed a crew of two, designated command-post supervisor and tracker, but DEFA have striven to make Entac a one-man missile. Many such improvements are being made, and we recently quoted a German rival as saying that the final, promised Entac "exists only on paper." Production has been farmed out to Nord. The US Fiscal 1961 purchase could be for some 17,000 rounds, at about $1,200 each, triggered off by the sudden crises in Indo China, Berlin and elsewhere.

MALKARA

Heavy missile for use from vehicles

BRITISH ARMY

IN anti-tank warfare anybody who fails to kill with his first shot rarely gets a chance for a second. While aware of the profusion of infantry missiles, the British War Office have long believed their lethality to be inadequate; and in August 1959 the sledgehammer Malkara was bought for use by the Royal Armoured Corps. Details of the missile, and its development by the Australian Government Aircraft Factories with assistance by the RAE, were given in the 1959 review. Fairey Engineering are UK foster-parent, and hold the sales-agency for all countries except the USA. British deployment will primarily be from an *ad hoc* air-droppable armoured vehicle with a crew of three, carrying two rounds on launchers and two stowed. Using a 60lb head containing 35lb h.e., Malkara is effective against any point target, such as a fort or bridge. Trials at Puckapunyal by the Australian Army and Department of Supply have demonstrated the accuracy and lethality of the missile; it can be made consistently to enter the slit of a bunker at ranges greater than a mile.

MOSQUITO

Light infantry missile

SWISS ARMY, "OTHER CUSTOMERS"

THE renowned armaments firms of Contraves and Oerlikon have now completed development of this missile, in which plastics and transistorization contribute to a low weight for its size. A rigid back-pack contains two Mosquitoes, wings unclipped, while the control unit is slung round the neck. The missile is launched directly from the ground, the forebody being supported by an adjustable rod. Arming is effected in flight either by a clockwork timer or a command signal from the operator. Contraves are in full production at Zürich, and have developed not only a simulator but a parachute recovery system for practice missiles.

NORD 5203 (SS.10)

Medium missile for infantry, vehicles or aircraft

FRENCH ARMY, *and forces of 13 other nations (Surface/Surface Missile 10)*

SS.10 was ready for service in 1953; more than 50,000 have now been delivered, out of Nord's present total of rather over 70,000 missiles of all types. Fully described in *Flight* for February 7, 1958, it costs about £340 and is widely used from Jeeps, slow aircraft and helicopters.

NORD 5210 (SS.11)

Heavy missile for infantry, vehicles or aircraft

FRENCH ARMY, NAVY AND AIR FORCE, *large evaluation orders by USA, Britain and Federal German Republic, and used by at least four other nations (Surface/Surface Missile 11)*

SS.11 weighs too much to be a popular infantry weapon, although Nord have evolved a scheme whereby four men can handle three missiles and equipment. The marine version can be used after the guidance wires have touched the sea, and various types of warhead may be fitted according to the target character. A full description appeared on November 14, 1958.

PYTHON

Heavy missile for infantry or vehicles

PRIVATE VENTURE

STARTING with a careful electronic analysis of guidance systems, Pye Ltd, of Cambridge, have progressively evolved an optimum system which is now being test-flown. The War Office is keeping a close watch on progress, but has not injected money. Flight development continues to show promise, and a unique feature currently being perfected is that, to minimize power required for roll-stabilization, only the rear end of the missile, containing the motor nozzles, is prevented from rotating.

VIGILANT

Medium missile for infantry

PRIVATE VENTURE

DESCRIPTIONS of this weapon system were published by *Flight* on May 22, 1959, and July 27, 1961. Since they were not working for a customer, Vickers-Armstrongs (Aircraft) were able to develop this weapon with speed and economy, and it has shown itself to be the most effective infantry anti-tank device in the world. Key to the ease with which an operator can learn, and retain, certain-kill accuracy is the fact that it has an airborne autopilot, making for smooth flight and instant response to operator demand. Other advantages stem from the absence of either smoke or flash at launch, the high flight speed, the small-span wings with trailing-edge controls, and the extremely effective warhead which weighs 36 per cent of missile weight. Large-scale evaluation has been successfully completed by British Army infantry, and Royal Armoured Corps trials are in hand with Vigilants fired from Ferret scout cars. Following 5hr simulator training, operators are consistently achieving turret-strikes with their first round; and moving tanks have been hit well off to one side at only 200yd range. Production has been assigned by British Aircraft Corporation to English Electric Aviation at Stevenage; it is the task of BAC to prove that Vigilant is "the most economical and certain tank-killing weapon ever devised for infantry," despite its high first cost.

Two Continental anti-tank weapons: left, the definitive version of the German Cobra, which requires no launcher; right, the Swiss Mosquito, which (like Cobra) is made largely of plastics

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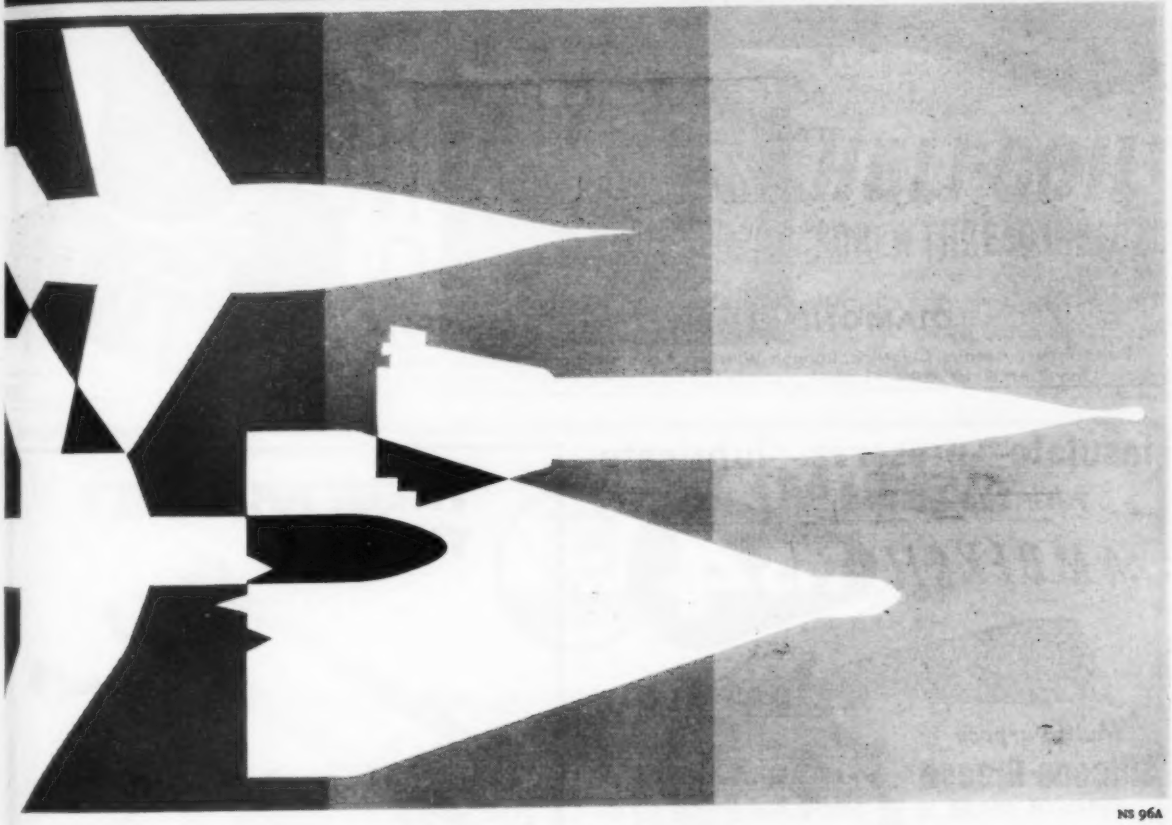

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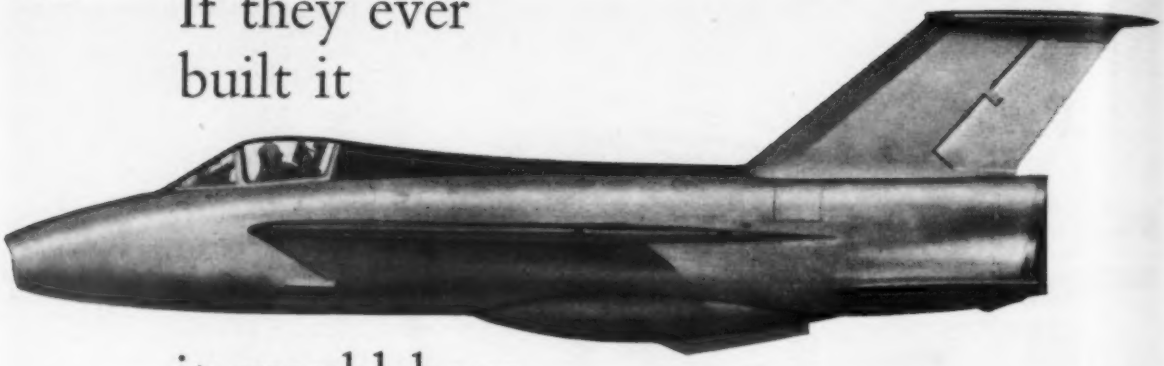

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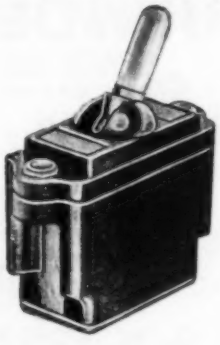

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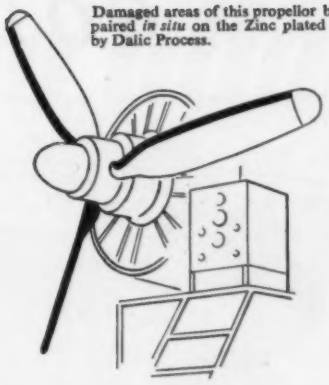
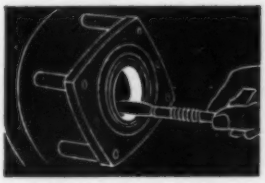


Damaged areas of this propellor blade repaired *in situ* on the Zinc plated surfaces by Dalic Process.



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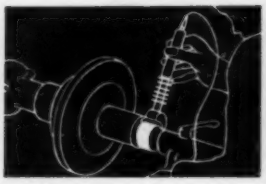

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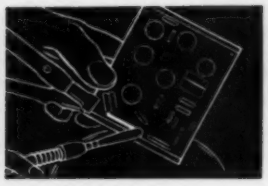

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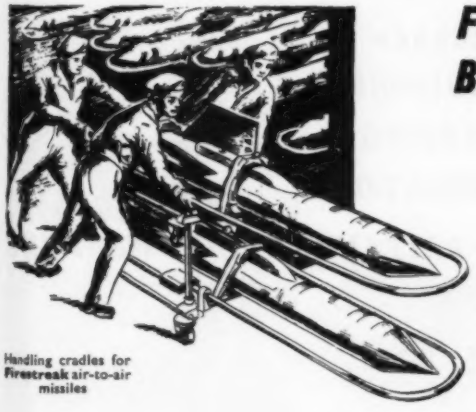

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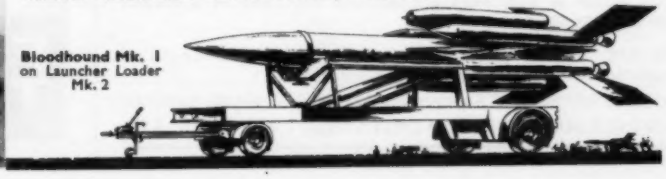

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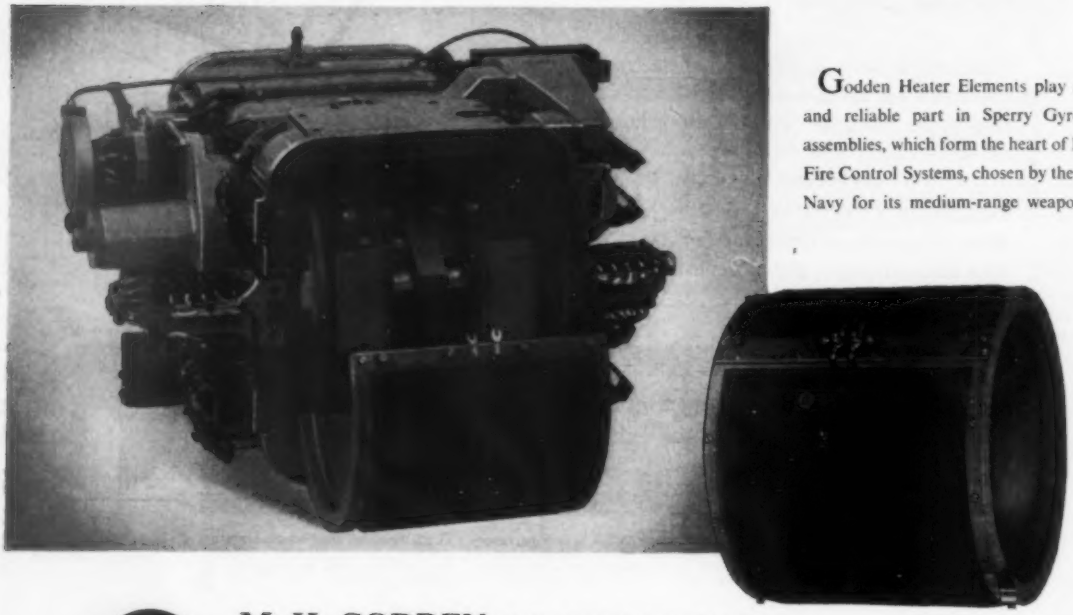

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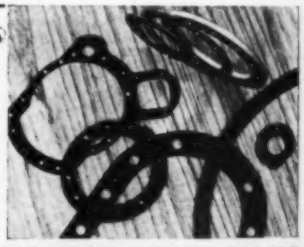

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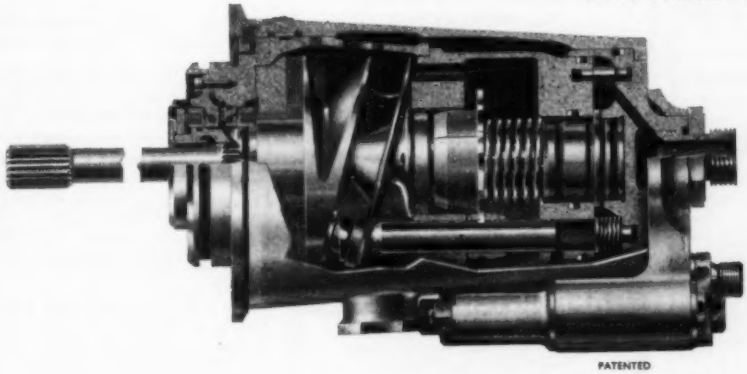

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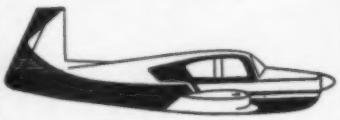

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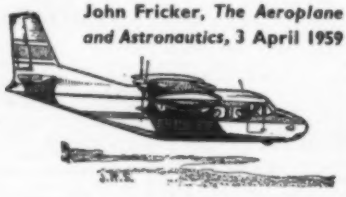
John Fricker, The Aeroplane and Astronautics, 3 April 1959



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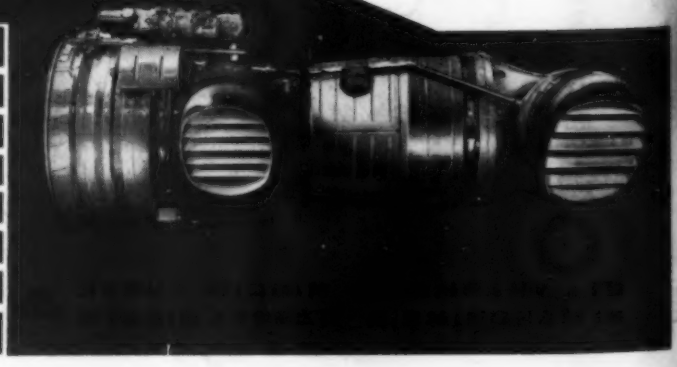

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